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THE NAVAL OBSERVATORY

SERVICE MONOGRAPHS
OF THE
UNITED STATES GOVERNMENT
No 39
INSTITUTE FOR GOVERNMENT RESEARCH

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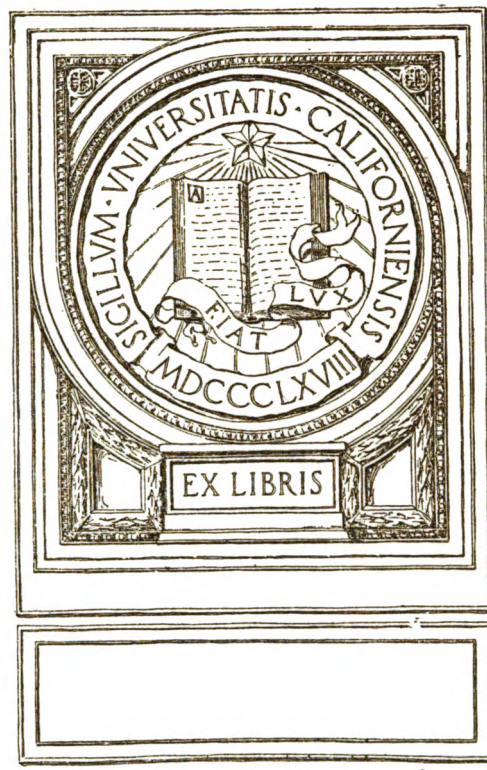

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THE NAVAL OBSERVATORY

ITS HISTORY, ACTIVITIES AND ORGANIZATION

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THE INSTITUTE FOR GOVERNMENT RESEARCH

Washington, D. C.

The Institute for Government Research is an association of citizens for coöperating with public officials in the scientific study of government with a view to promoting efficiency and economy in its operations and advancing the science of administration. It aims to bring into existence such information and materials as will aid in the formation of public opinion and will assist officials, particularly those of the national government, in their efforts to put the public administration upon a more efficient basis.

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SERVICE MONOGRAPHS
OF THE
UNITED STATES GOVERNMENT
No. 39

THE NAVAL OBSERVATORY

ITS HISTORY, ACTIVITIES AND ORGANIZATION

BY
GUSTAVUS A. WEBER

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FOREWORD

The first essential to efficient administration of any enterprise is full knowledge of its present make-up and operation. Without full and complete information before them, as to existing organization, personnel, plant, and methods of operation and control, neither legislators nor administrators can properly perform their functions.

The greater the work, the more varied the activities engaged in, and the more complex the organization employed, the more imperative becomes the necessity that this information shall be available—and available in such a form that it can readily be utilized.

Of all undertakings, none in the United States, and few, if any, in the world, approach in magnitude, complexity, and importance that of the national government of the United States. As President Taft expressed it in his message to Congress of January 17, 1912, in referring to the inquiry being made under his direction into the efficiency and economy of the methods of prosecuting public business, the activities of the national government "are almost as varied as those of the entire business world. The operations of the government affect the interest of every person living within the jurisdiction of the United States. Its organization embraces stations and centers of work located in every city and in many local subdivisions of the country. Its gross expenditures amount to billions annually. Including the personnel of the military and naval establishments, more than half a million persons are required to do the work imposed by law upon the executive branch of the government.

"This vast organization has never been studied in detail as one piece of administrative mechanism. Never have the foundations been laid for a thorough consideration of the relations of all of its parts. No comprehensive effort has been made to list its multifarious activities or to group them in such a way as to present a clear picture of what the government is doing. Never has a complete description been given of the agencies through which these activi-

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ties are performed. At no time has the attempt been made to study all of these activities and agencies with a view to the assignment of each activity to the agency best fitted for its performance, to the avoidance of duplication of plant and work, to the integration of all administrative agencies of the government, so far as may be practicable, into a unified organization for the most effective and economical dispatch of public business."

To lay the basis for such a comprehensive study of the organization and operations of the national government as President Taft outlined, the Institute for Government Research has undertaken the preparation of a series of monographs, of which the present study is one, giving a detailed description of each of the fifty or more distinct services of the government. These studies are being vigorously prosecuted, and it is hoped that all services of the government will be covered in a comparatively brief space of time. Thereafter, revisions of the monographs will be made from time to time as need arises, to the end that they may, as far as practicable, represent current conditions.

These monographs are all prepared according to a uniform plan. They give: first, the history of the establishment and development of the service; second, its functions, described not in general terms, but by detailing its specific activities; third, its organization for the handling of these activities; fourth, the character of its plant; fifth, a compilation of, or reference to, the laws and regulations governing its operations; sixth, financial statements showing its appropriations, expenditures and other data for a period of years; and finally, a full bibliography of the sources of information, official and private, bearing on the service and its operations.

In the preparation of these monographs the Institute has kept steadily in mind the aim to produce documents that will be of direct value and assistance in the administration of public affairs. To executive officials they offer valuable tools of administration. Through them, such officers can, with a minimum of effort, inform themselves regarding the details, not only of their own services, but of others with whose facilities, activities, and methods it is desirable that they should be familiar. Under present conditions services frequently engage in activities in ignorance of the fact that the work projected has already been done, or is in process of execution by other services. Many cases exist where one service could

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make effective use of the organization, plant or results of other services had they knowledge that such facilities were in existence. With the constant shifting of directing personnel that takes place in the administrative branch of the national government, the existence of means by which incoming officials may thus readily secure information regarding their own and other services is a matter of great importance.

To members of Congress the monograph should prove of no less value. At present these officials are called upon to legislate and appropriate money for services concerning whose needs and real problems they can secure but imperfect information. That the possession by each member of a set of monographs such as is here projected, prepared according to a uniform plan, will be a great aid to intelligent legislation and appropriation of funds can hardly be questioned.

To the public, finally, these monographs will give that knowledge of the organization and operations of their government which must be had if an enlightened public opinion is to be brought to bear upon the conduct of governmental affairs.

These studies are wholly descriptive in character. No attempt is made in them to subject the conditions described to criticism, nor to indicate features in respect to which changes might with advantage be made. Upon administrators themselves falls responsibility for making or proposing changes which will result in the improvement of methods of administration. The primary aim of outside agencies should be to emphasize this responsibility and facilitate its fulfillment.

While the monographs thus make no direct recommendations for improvement, they cannot fail greatly to stimulate efforts in that direction. Prepared as they are according to a uniform plan, and setting forth as they do the activities, plant, organization, personnel and laws governing the several services of the government, they will automatically, as it were, reveal, for example, the extent to which work in the same field is being performed by different services, and thus furnish the information that is essential to a consideration of the great question of the better distribution and coördination of activities among the several departments, establishments, and bureaus, and the elimination of duplications of plant, organization and work. Through them it will also be possible to

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subject any particular feature of the administrative work of the government to exhaustive study, to determine, for example, what facilities, in the way of laboratories and other plant and equipment, exist for the prosecution of any line of work and where those facilities are located; or what work is being done in any field of administration or research, such as the promotion, protection and regulation of the maritime interests of the country, the planning and execution of works of an engineering character, or the collection, compilation and publication of statistical data, or what differences of practice prevail in respect to organization, classification, appointment, and promotion of personnel.

To recapitulate, the monographs will serve the double purpose of furnishing an essential tool for efficient legislation, administration and popular control, and of laying the basis for critical and constructive work on the part of those upon whom responsibility for such work primarily rests.

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CONTENTS

CHAPTER PAGE

Foreword vii

I. History 1
Early Efforts for the Establishment of an Astronomical Observatory 2
Establishment of a Depot of Charts and Instruments . . . 8
Erection of a Permanent Depot and Observatory 13
Systematic Hydrographic, Meteorological, and Magnetic Work 17
Astronomical Work of the Depot of Charts and Instruments . 21
Legal Status of the Depot of Charts and Instruments and of Its Functions 24
Nautical Almanac Office, 1849 to 1894 26
The Naval Observatory, 1866 to 1926 28
Administration and equipment 29
Time service 34
Astronomical day 36
Longitude determination by telegraph and radio 37
Astronomical observations 38
International conferences 41
Executive Heads of the Naval Observatory and Nautical Almanac Office 41

II. Activities 46
Time Service 48
Preparation of American Ephemeris and Nautical Almanac . 51
Astronomical Observations for Position 53
Navigational Instruments 56
Coöperation with Astronomical Organizations 57

III. Organization 59
Offices of the Superintendent and Assistant Superintendent . . 59
Astronomical Council 59
Executive committee 60
Computing section 60
Library 60
Administrative Section 60
Office of the administrative assistant 60
Building and grounds force 61
Astronomical Branch 61
Department of astronomical observations 61
Division of equatorials 61
Division of nine-inch transit circle 62
Division of six-inch transit circle 62
Division of photographic zenith tube and alt-azimuth . . 62
Division of prime vertical transit instrument 63
Department of nautical almanac 63

Digitized by Google

CHAPTER PAGE

III. ORGANIZATION—Continued

Nautical Branch 63
Department of material 63
Magnetic compass division 64
Gyro-compass division 64
Air navigation and aerological instrument division . . . 64
Division of nautical instruments and time service . . . 65
Supply division 65
Inspection division 65

APPENDIX

1. Outline of Organization 66
2. Classification of Activities 70
3. Publications 72
4. Plant and Equipment 76
5. Laws 79
6. Financial Statements 86
7. Bibliography 90
Index 97

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UNIV. OF CALIFORNIA

THE NAVAL OBSERVATORY

ITS HISTORY, ACTIVITIES AND ORGANIZATION

CHAPTER I

HISTORY

The Naval Observatory is a branch of the Bureau of Navigation[1] of the Navy Department. The functions of the Bureau of Navigation are mainly military, but it is also charged with the upkeep and operation of the Naval Academy, the Naval Observatory, and the Hydrographic Office, and the conduct of all ocean and land surveys of the Navy Department.

The Naval Observatory maintains, continuously, observations of the heavenly bodies for improving the tables of the planets, moon, and stars and for determining the fundamental astronomical constants used in preparing the American Ephemeris and Nautical Almanac; prepares the American Ephemeris and Nautical Almanac; sends out daily time signals; and has charge of the development, supply, upkeep, repair, and inspection of navigational, surveying, aeronautical, and aerological instruments for the ships and aircraft of the Navy. These activities are not only necessary to the Navy and to the merchant shipping interests, but they also serve the general public throughout the country by furnishing accurate time which cannot be obtained from any other source and by supplying data to astronomers and other scientists.

Prior to the enactment of the act of June 21, 1866, the functions of the Naval Observatory and of the Hydrographic Office were performed under the same direction and in the same office—the Depot of Charts and Instruments—and the early histories

[1] There is also a Bureau of Navigation in the Department of Commerce which must not be confused with this bureau of the Department of the Navy. See Service Monograph of the U. S. Government, No. 15.

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of these two organizations are so interrelated that they are considered together. The historical account of this early period here given, is therefore identical with that published in the monograph on the Hydrographic Office of this series.

Early Efforts for the Establishment of an Astronomical Observatory. The earliest congressional action leading to the establishment of a national astronomical observatory resulted from a memorial to that body from an amateur astronomer, William Lambert, dated December 15, 1809, suggesting the establishment of a first meridian in the United States at the permanent seat of the government. Lambert had determined the longitude of the Capitol in Washington, and submitted his calculations with the memorial to Congress.

This memorial, with the accompanying papers, was referred to a select committee of the House of Representatives, which committee on March 28, 1810, made a favorable report to the House,[2] in which the following resolution was proposed:

Resolved, That it is expedient to make provision, by law, authorizing the President of the United States to cause the longitude of the City of Washington, from the observatory at Greenwich, in England to be ascertained with the greatest degree of accuracy; and also authorizing him, for that purpose, to procure the necessary astronomical instruments.

The report of this committee was laid on the table, but on January 23, 1811, it was referred to a second select committee.[3] This committe appears to have been discharged at its own request, and the memorial, with accompanying papers and astronomical calculations, was referred on February 23, 1811, to the Secretary of State for an opinion. In his reply, communicated to the House of Representatives July 3, 1812, James Monroe, Secretary of State, said:[4]

In admitting the propriety of establishing a first meridian within the United States, it follows that it ought to be done with the greatest mathematical precision, . . . For this purpose an ob-

[2] American State Papers, Misc., Vol. II, p. 53.
[3] House Journal, January 23, and February 23, 1811.
[4] American State Papers, Misc., Vol. II, p. 195.

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servatory would be of essential utility. It is only in such an institution, to be founded by the public, that all the necessary implements are likely to be collected together, that systematic observations can be made for any great length of time, and that the public can be made secure of the result of the labors of scientific men. In favor of such an institution it is sufficient to remark, that every nation which has established a first meridian within its own limits has established also an observatory.

Monroe's letter was referred to a third select committee on December 8, 1812, which on January 20, 1813,[5] reported "That in their opinion, astronomical observations are highly useful to a navigating and commercial people," and that "the most ready method of obtaining the information to be derived from noting the phenomena of the heavens, is by the establishment of an observatory. This may be erected at the City of Washington. By such an institution means may be adopted not only to fix the first meridian, but to ascertain a great number of other astronomical facts and occurrences through the vigilance of a complete astronomer."

The report was read a second time and referred to the committee of the whole house for January 22, 1813, but nothing further was done in the matter at that time.

On February 2, 1815, Lambert's original memorial was again referred, with the several reports and Monroe's letter, to a select committee of the House of Representatives, which reported on February 18,[6] recommending the carrying out of Lambert's plan by the establishment at public expense of an astronomical observatory and providing suitable instruments. It also recommended that the President of the United States be requested to cause further observations to be made to determine the exact longitude of the Capitol and that the results and data be laid before Congress at its next session. A resolution embodying the committee's recommendations was adopted February 18, 1815, but the President took no action under this resolution on the ground that it was not a joint resolution but was agreed to by the House of Representatives alone.[7]

[5] American State Papers, Misc., Vol. II, p. 197.
[6] *Ibid.*, pp. 273 and 759.
[7] *Ibid.*, p. 759.

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In November, 1818, Lambert presented another memorial to Congress in which he claimed that the abstract of astronomical calculations to ascertain the longitude of the Capitol, for the establishment of a first meridian according to the original plan of the city, was founded on the most accurate data obtainable when the observations were made, and that they had been admitted by the American Philosophical Society of Philadelphia into a volume of their transactions.[8] In this communication he did not urge the immediate erection of an observatory but solicited "the adoption of a concurrent resolution of the two Houses of Congress, authorizing additional observations to be made to test the accuracy of the result already obtained, by such methods as may be best adapted to insure a correct determination of our longitude from Greenwich."

This memorial was referred to a select committee, which on February 24, 1819,[9] reported the joint resolution asked for. This resolution was finally passed March 3, 1821 (3 Stat. LL., 648), and the President on April 10, 1821, appointed Lambert, who was instructed "to make astronomical observations by lunar occulations of fixed stars, solar eclipses, or any approved method adapted to ascertain the longitude of the Capitol from Greenwich."[10]

Lambert's report, dated November 8, 1821, was submitted to Congress January 8, 1822.[11] In it he gave the mean results obtained by different methods employed for determining the longitude of the Capitol. He closed his report with a recommendation for the establishment of an astronomical observatory in the following words:

The legislative and executive authorities of the National Government will decide on the utility or expediency of erecting an observatory and furnishing it with suitable instruments and apparatus. Without such an institution the right ascension, declination, longitude, and latitude of the moon, planets, etc., cannot be ascertained with sufficient accuracy; and any attempt to compile a nautical almanac or astronomical ephemeris for ourselves would

[8] Philosophical Transactions (New Series), Vol. I, p. 102.
[9] American State Papers, Misc., Vol. II, pp. 546, 769.
[10] Message of President Monroe, January 8, 1822.
[11] American State Papers, Misc., Vol. II, p. 753.

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be futile, if not preposterous. Until an observatory be erected and furnished, we shall be compelled to rely upon the labors of scientific men for the elements necessary to be used in our astronomical calculations.

Supplementary reports by Lambert were submitted to Congress by the President on March 12, 1822,[12] and December 23, 1823. The latter was referred to the Joint Committee of the Library, and a report was made upon it February 25, 1824,[13] but laid on the table, and there appears to be no record of any subsequent action on the matter.

One of the most ardent advocates of an astronomical observatory was John Quincy Adams, who as President, and subsequently as a member of Congress, persistently endeavored to secure legislation for its establishment.

In his first message to Congress, dated December 6, 1825, President Adams urged the establishment of a national university in which he said: "Connected with the establishment of an university, or separate from it, might be undertaken the erection of an astronomical observatory, with provision for the support of an astronomer, to be in constant attendance of observation upon the phenomena of the heavens, and for the periodical publication of his observations."

This part of the President's message was referred to a select committee, which presented on March 18, 1826, an elaborate report[14] prepared by Major-General A. Macomb, Chief of Engineers of the War Department, designating a suitable position for an observatory and indicating the proposed duties and responsibilities of the astronomer to be placed in charge. The committee also submitted a bill for the establishment of an observatory in the District of Columbia. Attention was called in the report to the fact that the requisite instruments and books for such an observatory were already in the possession of the government, and an estimate was made of $14,500 for the cost of erecting the observatory, and $4000 for the annual cost of operation. General Macomb recommended that "As soon as circumstances would per-

[12] American State Papers, Misc., Vol. II, p. 794.
[13] House Journal, February 25, 1824.
[14] 19 Cong. 1 sess., H. rep. 124.

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mit, a nautical almanac or astronomical ephemeris should be prepared and published for the use of the Navy and commercial marine." These requisite instruments which had been procured for the Survey of the Coast during Jefferson's administration, instead of being set up and applied to their proper uses, were, at this time stored away in one of the rooms of the War Department. Accompanying General Macomb's report were a letter from Major Kearney, his subordinate, giving details of a plan for an observatory building, and a letter from an attaché of the Russian legation, De Wallenstein, pointing out the advantages to be expected from such an institution.

The committee's report and bill were committed to the committee of the whole house for the following Monday, but the House Journal shows no further trace of them, and no action appears to have been taken on this matter for several years.

In response to a letter of inquiry from the chairman of the House Committee on Naval Affairs, the Secretary of the Navy, in a letter dated March 18, 1830, gave the following reasons for the establishment of an astronomical observatory:

1st. In a national point of view, as it would furnish the means of making such observations as would enable astronomers to ascertain or calculate the positions of the heavenly bodies at any time without being dependent on other nations for the same; and would be, moreover, a fixed point to whose meridian (commonly called a first meridian when used for geographical purposes) terrestrial objects may, with certainty, be referred, as far as respects their longitudes.

2d. It would, furthermore, be desirable in a scientific point of view, as it would present the means of comparing certain astronomical results, for the purpose of determining the figure of the earth and improving theories relative to the motions of the planetary bodies.[18]

In a subsequent report, December 5, 1835, the Secretary of the Navy said:

A national observatory, although not immediately necessary to the defense of our country, is remotedly so; and, considered with

[18] Nourse, Founding and progress of the United States Naval Observatory, p. 12.

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reference to the bearing it would have upon our Navy, our commerce, and scientific pursuits, it assumes an importance worthy of the consideration of Congress. . . . It would not be attended with any great expense. It is necessary now to employ an officer of science to keep our maps and charts, to regulate our chronometers, and to preserve all mathematical and philosophical instruments required for the Naval Service; and buildings are necessary for these purposes. These duties would probably devolve upon the Superintendent of the Observatory; and the buildings necessary to such an establishment would be amply sufficient for the preservation of our maps, charts, and instruments.[16]

There is no record of an endorsement of this proposition by the President, or of any congressional action in response thereto.

In June, 1838, when the Smithsonian bequest was received, John Quincy Adams entreated President Van Buren to recommend to Congress a definite plan for the foundation of a Smithsonian Institution, suggesting in connection therewith "the establishment of an astronomical observatory with a salary for an astronomer and an assistant for nightly observations, and periodical publications; annual courses of lectures upon natural, moral and political sciences."[17]

On October 14, 1838, Adams made a lengthy report, in response to a letter from the Secretary of States by direction of the President, in which he strongly advocated the establishment of an astronomical observatory out of the income from the Smithsonian bequest, and in which he laid down the principles for the disposal of the funds for this purpose.

On March 5, 1840, as chairman of a select committee of the House of Representatives on the Smithsonian Fund, Adams said:

The express object of an observatory is the increase of knowledge by new discovery. . . . There is no richer field of science opened to the exploration of man in search of knowledge than astronomical observation; nor is there, in the opinion of this committee, any duty more impressively incumbent on all human governments than that of furnishing means, and facilities, and rewards, to those who devote the labors of their lives to the indefatigable industry, the increasing vigilance, and the bright intelligence indispensable to success in these pursuits.[18]

[16] Nourse, Founding and progress of the United States Naval Observatory, p. 13.

[17] Quincy, Memoir of the life of John Quincy Adams, p. 287 (1858).

[18] 27 Cong. 1 sess., H. rep. 277.

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In his third report on the Smithsonian Fund,[19] submitted to the House of Representatives, April 12, 1842, Adams again urged the establishment of a national observatory, and presented a bill for the appropriation of a portion of the income from the Smithsonian Fund for the creation of an observatory, the payment of the salaries of an astronomer and assistants, for the purchase of the best and most perfect instruments, for the purchase of a library of science and literature, and for the publication of astronomical observations and a nautical almanac. This bill was not enacted.

Another bill introduced in Congress the same year in response to certain citizens of Philadelphia, New York, and Baltimore, who had memorialized Congress to take measures for the reduction of astronomical observations and for the precise determination of the longitude of the Capitol, also failed of enactment.

The opinion is expressed in Quincy's Memoir[20] that the powerful opposition to the establishment of an astronomical observatory during this period was due in a large measure to political enmity toward Adams. For many years, in every appropriation act by the terms of which there might have been a possibility of establishing an observatory, there was inserted the restriction "and to no other." In an act approved July 10, 1832 (4 Stat. L., 570, 571), providing for the survey of the coasts of the United States, the limitation was inserted, "that nothing in this act, or the act hereby revised, shall be construed to authorize the construction or maintenance of a permanent astronomical observatory." Even the measures to carry into effect the bequest of the Smithsonian Fund were defeated until the provision for an astronomical observatory was eliminated.

Notwithstanding this opposition in Congress, matters were shaping themselves in the meantime for the establishment of an astronomical observatory without specific legislation and in a way perhaps not contemplated by the early advocates or opponents of such an institution, and in this way Adams's desire was fulfilled some years before his death.

Establishment of a Depot of Charts and Instruments. Prior to the year 1830, each vessel of the Navy when fitted out obtained

[19] 27 Cong. 2 sess., H. rep. 587.
[20] Quincy, p. 414-15.

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the necessary charts and instruments upon requisition by the commanding officer on the Board of Naval Commissioners, the purchases being made by a navy agent from foreign governments or from private dealers. No tests were made of the accuracy of the instruments and charts prior to their purchase. When a ship was put out of commission, its books, charts, and instruments were tumbled into store-rooms, where they remained, neglected, until needed for another vessel. Often they were found unfit for use after such storage.

In order to provide for the proper testing and examination of instruments and charts and for their care and preservation when not in use, the Board of Naval Commissioners, on November 29, 1829,[21] made a recommendation to the Secretary of the Navy:

> That an officer be appointed to take charge of all the nautical instruments, books, and charts not on board ship, to keep them in order for use when required. Among other duties he would be required to attend particularly to the time pieces, or chronometers, to ascertain precisely their character, such as their rate of deviation from time to time, whether they are affected by changes of weather, etc., for the information of those who may have to use them at sea. The character of each chronometer thus ascertained shall be delivered to the officer receiving the chronometer itself.

The following year, Lieutenant L. M. Goldsborough, calling attention to the Board's report, made the following specific suggestions for the establishment of a depot of charts and instruments.[22]

> First, That a suitable place be designated to serve as a general depot for all chronometers, instruments of reflection, theodolites, circles, telescopes, charts, etc., belonging to the Navy. At present, such instruments as are not on ship-board are dispersed about among the naval stores of our yards, in charge of individuals perfectly unacquainted with such matters, and corroding and becoming ruined for want of proper attention.
>
> Second, That to this depot there be attached a competent officer, and an artist of known merit and capacity—the former to act under the immediate orders of the Navy Commissioners, to be

[21] Navy Commissioners, Letters to the Secretary of the Navy, Vol. 3, p. 280. Files of the Navy Department.

[22] Officers' Letters to Secretary of the Navy, Vol. IX, p. 53. Files of the Navy Department.

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made personally responsible for all instruments submitted to his charge, and especially required to determine the rates and characters of chronometers, to make it his duty to inform himself of all improvements and discoveries in connection with navigation, and to furnish upon requisitions, approved by the Navy Board, all ships fitting out with their necessary nautical apparatus; the latter to repair, clean, adjust, assist in rating, etc. to the end that all instruments may be kept in proper order, and at all times ready for use. He should be required also to examine and test thoroughly all chronometers previous to their being purchased.

These suggestions of Lieutenant Goldsborough, having been approved by the Secretary of the Navy and the Board of Navy Commissioners, the Secretary, on December 6, 1830, ordered that a Depot of Charts and Instruments should be established in Washington, with functions practically as outlined in Lieutenant Goldsborough's letter. This officer, who was placed in charge of the Depot, was directed to collect from the commandants of various navy yards, the nautical instruments, books, and charts not in use, and transport them to the Depot. These were systematically arranged, marked, and put in condition for issue.

Among the functions of the Depot, as outlined in the Secretary's order, was the ascertaining of errors and rates of all chronometers sent to United States vessels being fitted out for sea. This was accomplished by means of sextant and circle observations. For this purpose a thirty-inch transit instrument was obtained and mounted in a circular building near the house rented for the Depot, on what is now G. Street, between Seventeenth and Eighteenth streets, N. W., in Washington. This was the first astronomical instrument for the Navy Department erected in Washington.

On July 31, 1831, an assistant, also a naval officer, was assigned to the Depot. It was made the duty of these officers, among others, to have charge of the purchase of all charts and chronometers, as well as the sale of such of the latter or of any nautical instruments, as were not adapted to the wants of the Navy, and the care and issue of charts and instruments furnished to United States vessels on fitting out for sea. All chronometers purchased by the Navy Department were submitted to tests at the Depot before they were accepted.

At the time of the establishment of the Depot, the charts and nautical books were purchased at private stores; they were nearly

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all of European origin and calculated from meridians to which our service was not accustomed; and the sailing directions were often in foreign languages. Upon Lieutenant Goldsborough's suggestion, he was directed by the Board of Navy Commissioners to make such modifications of the charts as would reduce them to the meridian of Greenwich, England, and to translate the notations and instructions into the English language. A strong appeal was made by Lieutenant Goldsborough for the purchase of a lithographic press, but this was not authorized until some years later.

In 1833 Lieutenant Goldsborough was succeeded by Lieutenant Charles Wilkes, who in 1834 removed the Depot to Capitol Hill on a site originally proposed in 1816 by Ferdinand R. Hassler, Superintendent of the Coast Survey, about a thousand feet north of the dome of the Capitol, where it remained until July, 1842.

At this place, Lieutenant Wilkes erected at his own expense, an observatory sixteen feet square, and mounted a transit made by Edward Troughton in England for the Coast Survey in 1815 and loaned for the purpose by the Survey. This transit instrument had an object glass of 3¾-inches aperture and sixty-three inches focal length. There were also installed a Borda circle, a 3½-foot achromatic portable telescope, a portable transit instrument, and a sidereal clock. It does not appear, however, that any regular series of observations were made at this time, except for the rating of chronometers.

In May, 1835, a lithographic press was installed at the Depot, and the work of chart production was begun. Consideration was now given by the Navy Department to the undertaking of original hydrographic work, and in 1836, Lieutenant Wilkes was instructed to proceed to Europe and purchase scientific instruments to be used for the Exploring Expedition, provision for which had been made by Congress in an act (May 14, 1836; 5 Stat. L., 27, 29), which authorized the President "to send out a surveying and exploring expedition to the Pacific Ocean and [the] South Seas, and for that purpose to employ a sloop of war, and to purchase or provide such other smaller vessels as may be necessary and proper to render the said expedition efficient and useful." The President was authorized to expend not to exceed $300,000 for this purpose.

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In the spring of 1837, Lieutenant Wilkes was relieved from duty at the Depot and was detailed to make a survey of the shoals of George's Bank, a work which was required by the act of March 3, 1837 (5 Stat. L., 157), and Lieutenant James M. Gilliss was placed in charge of the Depot.

In the winter of 1837-38, while Lieutenant Wilkes was surveying the entrance to Savannah River, Lieutenant Gilliss, made certain astronomical observations at his request, but these were never reduced.

In 1838 the United States Government sent out its first scientific expedition under authority of the act of May 14, 1836, and Wilkes, now a Commander, was placed in charge. The authority given covered explorations and surveys of the Pacific Ocean and the South Seas, "to determine the existence of doubtful dangers reported in the track of the United States trade, to make astronomical observations for locating shoals, islands, reefs, etc.; observations of terrestrial magnetism, variation of the compass, etc.; to instruct the natives of the islands visited in agriculture and horticulture, and to encourage them to increase their output; to discover if possible a shorter route to China *via* the Sulu Sea." [22] The scientific staff of the Expedition included a philologist, two naturalists, a conchologist, a mineralogist, a botanist, a horticulturist, and two draftsmen.

The importance of observing corresponding moon culminations, occultations, and eclipses, in determining the differences of longitude between the observatory and the stations which the Expedition might occupy abroad was suggested to the Department at this time, and Lieutenant Gilliss at the Depot and William C. Bond at Boston were instructed under orders of the Secretary of the Navy dated August 13, 1838, to make such observations during the absence of Commander Wilkes. Provision was made at the same time by the Secretary of the Navy for the purchase of all necessary supplies and instruments for making a constant series of observations in astronomy, magnetism, and meterology, and Lieutenant Gilliss accordingly obtained a portable forty-two-inch achromatic telescope, mounted parallactically [equatorially]; a variation transit; a comet seeker; an eight-inch dip-circle; and

[22] Hydrographic Officer, Annual Report, 1924, p. 40.

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a sidereal chronometer; and subsequently, two clocks, one a sidereal and one a mean-time clock, and a balance magnetometer. The astronomical observations, made at the Depot under these instructions were begun in September, 1838, and continued to 1842.

The purchase of these instruments and the taking of these continuous observations laid the foundation for the establishment of a permanent naval observatory.

The results of Wilkes' Exploring Expedition were ordered to be published by an act of Congress approved August 26, 1842 (5 Stat. L., 534), which provided "that there shall be published, under the supervision and direction of the Joint Committee on Library, 'an account of the discoveries made by the Exploring Expedition, under the command of Lieutenant Wilkes of the United States Navy'; which account shall be prepared with illustrations and published in form similar to the voyage of the Astrolabe, lately published by the Government of France." The act provided for the printing of one hundred copies, but subsequent acts provided for reprints and for their distribution. The publication appeared in the form of twenty-four quarto volumes and eleven atlases, issued at intervals from 1844 to 1874. Volume XXIII, Hydrography, by Wilkes, comprising 514 pages and an atlas containing 106 charts, was published in 1858-61.

In 1837 four engraved charts, being the first issue by the Navy Department, were published by the Depot from surveys made by American naval officers, and during the succeeding five years, eighty-seven such charts were issued, nearly all of which were the results of surveys made by the Exploring Expedition. The charts published by the Depot during its existence of about thirty-five years were engraved under contract by private parties.

Erection of a Permanent Depot and Observatory. The work of the Depot of Charts and Instruments, especially its hydrographic and astronomical work, had taken on such a character since its creation in 1830, that the accommodations became unsuitable and inadequate. From year to year, therefore, efforts were made by the Board of Navy Commissioners and by individual officers to secure the establishment of a permanent buildng for an enlarged Depot and an observatory.

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Finally, on November 30, 1841, the Board of Navy Commissioners, at the solicitation of Lieutenant Gilliss, addressed a letter to the Secretary of the Navy, strongly urging an appropriation for such a permanent building. This recommendation was endorsed by the Secretary of the Navy in a report to the President.[34]

Subsequently a bill to that effect was introduced in Congress. After reference to the naval committees of the House and Senate, and much delay, the measure, known as the "Mallory bill," was approved August 31, 1842 (58 Stat. L., 576).

The activities, problems, and needs of the Depot of Charts and Instruments at that time are described in the following extracts from the report of the House Committee on Naval Affairs which accompanied this bill:[35]

Since its organization, the Navy has not only been furnished with better instruments and more recent charts, at a greatly less original cost than before, but greater care has been observed in their use. . . .

Prior to that time, chronometers were purchased as the wants of a ship or the judgment of a commander dictated, without trial or examination, the only guarantee of its value being the word of the seller. . . .

The same set of instruments rarely went to sea two cruises. When the ship returned, they were tumbled into the navy store, chronometers and all, where they remained till the fitting of a new ship would find them unworthy for further use. . . .

In the summer of 1838, the honorable Secretary of the Navy directed the superintendent to make a constant series of observations in astronomy, magnetism, and meterology, ordering an additional number of assistants, and granting authority for the purchase of all necessary instruments.

In the two latter sciences, the observations are made tri-hourly, throughout the day and night, from year's end to year's end; and, in the former, the average number of observations is three thousand annually. On a fixed day of each month, the magnetic instruments are observed, at intervals of two minutes and thirty seconds for twenty-four hours, making the total number of observations during the day, with those instruments alone, 576. . . .

Hydrography. It is particularly desirable that information on this subject should be collected from all quarters, as well for the navy as for the commercial marine generally; and there is,

[34] Report of A. P. Upshur, Secretary of the Navy, December 4, 1841.
[35] 27 Cong. 2 sess., H. rep. 449.

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no doubt, a great mass of such information locked up in the memories of our whalers and Indiamen. . . . Yet from the fact that they know not where to send it, perhaps it never passes beyond the immediate crew.

The depot of charts and instruments is the proper receptacle of such information, till the organization of an appropriate hydrographic bureau. Let the captains of our merchant ships know they will be thanked for its communication, and receive credit as public benefactors, and there can be no doubt, great pride will be taken in its transmission. . . .

Astronomy. We are indebted to other nations for the data which enables our ships to cross the ocean. Not only has the navy failed to contribute to the common stock from which all our navigators borrow, but our country has never yet published an observation of a celestial body, which bore the impress "by authority"; and it is believed that, until the observations before alluded to in this report, none have ever been directed by the Government which can be considered continuous. . . .

A small observatory is absolutely essential to the Depot; without it, the duties cannot be performed. . . .

Magnetism. . . . Without a knowledge of the variation of the compass, none but coasting crafts dare venture beyond the precincts of a harbor; yet how few have more than a practical knowledge of the mode of determining its amount. The daily changes of the variation, its extraordinary fluctuations during auroras, the causes, amounts, and modes of correcting the local attraction of ships, and, indeed, the laws governing magnetized bodies generally, are mysteries with which a large portion of the officers have had neither means nor opportunities to become acquainted. Great complaints are made that chronometers perform badly; that ships have been influenced by currents, when, if the true cause could be ascertained, it would be found to consist in having steered a wrong course, no allowance being made for local attraction. . . .

Meteorology. To be a good judge of the weather is considered an important qualification for a seamen; the safety of a ship and her crew may depend on the promptness and accuracy of his judgment. . . . If the theory [Professor Espy's theory of storms] is correct, the day is not distant when we shall be able, by means of a barometer and windvane, to calculate the precise point where a storm is raging. Navigators will thus be enabled to steer clear of it, and take advantage of the favorable winds blowing in its outer edge. Meteorological observations are more important at night than by day, because of their scarcity hitherto; . . . and we can only hope to obtain the desired information when those engaged in its pursuit have duty to compel a flagging inclination.

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The act of August 31, 1842, authorized the Secretary of the Navy "to contract for the building of a suitable house for a depot of charts and instruments of the Navy of the United States on a plan not exceeding in cost the sum of $25,000," and required "that the said establishment may be located on any portion of the public land in the District of Columbia which the President of the United States may deem suited to the purpose."

While the act made no mention of an astronomical observatory, and no specific legal provision had ever been made for the taking of astronomical observations, the site was selected and the building plans were made with the view of establishing such a permanent institution. Thus, in the very year when Congress finally refused to enact Adams's bill for an astronomical observatory, it enacted a law which made it possible for the Navy Department to establish such an institution.

The duty of preparing a plan for the new Depot was entrusted to Lieutenant Gilliss, who, after going abroad and consulting with distinguished European astronomers, submitted on November 23, 1843, designs and drawings for a building suitable both for a depot of charts and instruments and for an astronomical observatory. These plans were adopted and the work of construction was immediately begun. With reference to the astronomical work Lieutenant Gilliss said in a report (1845), that he would have regarded his time as misspent to labor so earnestly only to establish a depot of charts and instruments; that his aim was "to place an institution under the management of naval officers, where, in the practical pursuit of the highest known branch of science, they would compel an acknowledgment of abilities hitherto withheld from the service." "Regarding this only as a naval observatory," he continued, "it is of the utmost importance that we give the service the greatest possible benefit from it."[26]

In his annual report for 1843, the Secretary of the Navy said, "It is proper to remark that this building is adapted in form and structure not only for a Depot of Charts and Instruments, but for an astronomical observatory."

[26] 28 Cong. 2 sess., S. ex. doc. 114, p. 66. This is a report from Lieutenant Gilliss communicated by the Secretary of the Navy to the Senate, February 17, 1845. It gives a detailed description of the building erected and of the astronomical and magnetic instruments to be installed.

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The site chosen by President Tyler for this Depot was a knoll sometimes called Braddock Hill on the government reservation marked "No. 4" in the original plan of Washington, where the Naval Medical School Museum of Hygiene is now located, from Twenty-Third to Twenty-Fifth streets, N. W., and from E Street, N. W. ["University Square"], to what is now Potomac Park.

The new building being ready for occupancy the latter part of 1844, Lieutenant M. F. Maury, who had relieved Lieutenant Gilliss as Superintendent of the Depot of Charts and Instruments, July 11, 1842, was ordered to take charge and to remove all the nautical books, charts, and instruments, with the officers, to the new quarters. The instruments and charts had been temporarily housed, since July 1, 1842, in a rented building known as 2222 and 2224 Pennsylvania Avenue, N. W.

Systematic Hydrographic, Meteorological, and Magnetic Work of the Depot. Lieutenant Maury, who took charge of the new depot and observatory on October 1, 1844, was inclined more toward the development of the hydrographic and meteorological work than his predecessor, who was, above all, an astronomer. While considerable work had been done in the field of hydrography by Wilkes and other officers, it was Lieutenant Maury who really laid the foundation for the systematic hydrographic work of the Navy Department.

Immediately upon taking charge of the Depot, Lieutenant Maury took steps to organize an extensive system of collecting information from the logs of men-of-war and merchant vessels. He succeeded in having observations made on a large number of ships, both in the Navy and Merchant Marine in all parts of the world, of the ocean currents, winds, air pressure and temperature, water temperature, and other marine and meteorological phenomena. In this way he was enabled to make charts of "the prevailing winds and currents, their general characteristics, and all the physical features of the ocean, including its meteorology, the limits of icebergs, the feeding grounds of whales, and all facts of interest and value to the maritime community."[27]

The compilation of this information and the preparation of the charts, required the attention of a large part of the force at

[27] 49 Cong. 1 sess., S. rep. 1285, pp. 26, 27.

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the Depot. Much difficulty was experienced, in the beginning, in obtaining the coöperation of the merchantmen.

The charts which were prepared from this material during Commander Maury's régime, 1844 to 1861, were known as "Wind and Current Charts." They consisted of six series, designated, respectively, as Track Charts, Trade-Wind Charts, Pilot Charts, Whale Charts, Thermal Charts, and Storm and Rain Charts.

The first three of the Track Charts were issued early in 1848 when copies were distributed gratuitously to naval officers and to the captains of merchant vessels who had contributed their logs. The charts covered the North Atlantic Ocean, and showed the tracks of a great number of vessels, the month in which each passage was made, the character of the weather, and the prevailing winds and currents encountered by each vessel. In 1849 the series of eight track charts covering the whole of the North Atlantic and a portion of the South Atlantic was completed.

The other series of Wind and Current Charts were issued from time to time, as they were successively completed, and their scope was gradually extended to include every navigable sea. In addition eight editions of Sailing Directions were issued in ten volumes. These contained information upon a vast number of subjects connected with the navigation of the ocean.

In commendation of this work, the Secretary of the Navy, in his annual report dated November 29, 1851, said: "The wind and current charts planned by Lieutenant Maury are being extended to the Pacific and Indian oceans. . . . This work has materially shortened the passage along the highways by which our commerce passes into and through the southern hemisphere."

During the period, 1844 to 1861, there were issued and gratuitously furnished to merchant vessels alone, twenty thousand copies of Sailing Directions and two hundred thousand copies of Wind and Current Charts. There were engraved and published, forty-four general sailing charts, all from surveys of the North Pacific Surveying Expedition under Commander John Rodgers, and plans of anchorages and passages in the Lu Chu (Ryu Kyu) groups, from surveys of the Exploring Expedition under Commodore Matthew C. Perry.

At the same time meteorological and magnetic observations were made at the Depot, and the other functions of observing the

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errors and rates of chronometers and examining, purchasing, and issuing charts, instruments, and nautical books to vessels of the Navy, were looked after.

From 1852 to 1854, Commodore Perry conducted an expedition to Japan, which, though of a diplomatic nature undertaken for the purpose of opening ports for trade with the United States, made surveys and other observations and collected much nautical and scientific information. A narrative of this expedition was published in three volumes.[28]

From 1853 to 1859, an expedition originally under the command of Commodore Cadwalader Ringgold, but later under Lieutenant John Rodgers, surveyed the North Pacific Ocean. This expedition was authorized, August 31, 1852 (10 Stat. L., 100, 104), and $125,000 was appropriated for the purpose. As a result of its work, the government was enabled to publish detailed coasting charts of the entire coast of Japan, the coasts and islands of the Bering Sea, and of a portion of the Arctic Ocean. Elaborate scientific studies were made on this expedition, but the results were not published.

Commander Maury devoted much of his attention, in addition to the other hydrographic and the astronomic work, to the physical geography of the oceans. The characteristic investigations of the Depot, instituted by him dealt with: "The form and divisions of the marine areas of the globe, with the winds that blow over the surface waters and their agency in minimizing the duration of the passages of ships, the contours of the ocean bed from the sea level down to the greatest depths, the temperature, the circulation, the physical and chemical properties of sea water, the currents, tides, waves, the composition and distribution of marine deposits, the nature and distribution of marine organisms and the modifications brought about in living things by the conditions of their existence, the relation of man to the ocean in the development of fisheries, commerce, civilization, navigation, hydrography, and marine meteorology."[29]

The researches made by the Depot of Charts and Instruments for the benefit of navigation and commerce were early brought

[28] Perry, United States Japan expedition (1856).
[29] Origin and mission of the Hydrographic Office, p. 3 (1918).

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to the attention of other governments, and as a result, an international conference, proposed by Maury, was held at Brussels, Belgium, in August and September, 1853, for the purpose of securing a uniform system of observations at sea. A form of abstract log and a plan of observations at sea, recommended at this conference, were adopted by nearly all the maritime nations through their navies and the voluntary coöperation of their merchantmen.

Commander Maury, like other meteorologists of the period, was strongly in favor of a system of reporting daily weather conditions on land by means of the telegraph, as is now being done by the Weather Bureau, and he advocated it in several of his publications.

Commander Maury joined the confederate forces in 1861, and was replaced by Commander Gilliss, his predecessor in charge of the Depot.

During the Civil War period, the hydrographic work of the Depot (Naval Observatory) was largely concentrated upon the purchase, care, and distribution of charts, compasses, spy-glasses, chronometers, and other navigating instruments, to nearly six hundred active cruising vessels engaged in the war. While as much of the hydrographic work as possible was maintained, the soliciting of meteorological data from merchant vessels for use in the preparation of charts was temporarily discontinued. During this period the Depot published charts of the Compass Stations at New York, Boston, Hampton Roads, the Delaware River, and Portsmouth, N. H.

An elaborate report, accompanied by maps and profiles, was made by the Depot, in response to a Senate resolution of March 19, 1866,[20] calling upon the Secretary of the Navy to furnish "the summit levels and distances by survey of the various proposed lines for interoceanic canals and railroads between the Atlantic and Pacific oceans, as also their relative merits as practical lines for the construction of a ship canal, and especially as relates to the Honduras, Tehuantepec, Nicaragua, Panama, and Atrato lines."

[20] Naval Observatory, Report on interoceanic canals and railroads between the Atlantic and Pacific oceans. 39 Cong. 1 sess., S. ex. doc. 62.

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Astronomical Work of the Depot of Charts and Instruments. Observations of the sun, moon, planets, and brighter stars were begun in January, 1845, and these objects have been continuously observed since that time. The results of the observations made in the year 1845 were published in September, 1846. This publication was characterized as the first volume of astronomical observations "ever issued from an institution properly entitled to the name of an observatory on this side of the Atlantic."[21]

In addition to this regular work of the Observatory, there was taken a series of zone observations of fainter stars, in accordance with the second paragraph of the order issued on March 6, 1846, by the Secretary of the Navy to the Superintendent of the Depot of Charts and Instruments. The order read:

Desirous that the numerous and able corps employed at the National Observatory at Washington may produce results important to maritime science and to the Navy, I approve your course in making the series of astronomical observations necessary for the preparation of a nautical almanac.

The country expects also that the observatory will make adequate contributions to astronomical science. The most celebrated European catalogue of the stars, Bessel's Zone Observations and Struve's Dorpat Catalogue of double stars, having extended to only 15° south of the equator, and the Washington Observatory by its geographical position commanding a zone of 15° farther south, and being provided with all instruments requisite for extending these catalogues, you are hereby authorized and directed to enter upon the observation of the heavens, commencing at the lowest parallel of south declination you may find practicable. You will embrace in your catalogue all stars, even of the smallest magnitude, which your instruments can accurately observe. You will, when convenient, make duplicate observations of stars for each catalogue, and when time permits, you will determine with precision, by the meridian instruments, the position of the principal stars in each pair or multiple of stars. Simultaneously with these observations you will, as far as practicable, determine the position of such stars as have different declinations or right ascensions assigned to them in the most accredited ephemerides.

The observations for making this catalogue of stars were begun on March 21, 1846, with three meridian instruments, the mural

[21] Letter of Lieutenant Maury, Superintendent of the Depot, to the Secretary of the Navy.

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circle, the meridian circle, and the transit instrument, and were discontinued in the year 1852. The zones made with the meridian circle in 1846 were published in 1860. Most of the remaining zones made in 1846 to 1849 were published in three appendices to the Washington Observations, 1869, 1870, and 1871. The remaining zones were never published as such, but were included with the published ones in the formation of a general catalogue which appeared in 1911 as Volume VII, Publications of the U. S. Naval Observatory, Second Series.

In referring to these observations in his annual report for 1846, the Secretary of the Navy said that with the facilities of the observatory we might produce our own nautical ephemeris, a small appropriation being sufficient to accomplish the object, the expenditure for which would be returned by supplying our merchant vessels with nautical almanacs at cost.

The Naval Observatory was brought into considerable prominence among astronomers throughout the world in 1847, through the discovery by one of the astronomers of the observatory staff, Sears C. Walker (February 1, 1847), that the planet Neptune, which had been discovered September 23, 1846, was identical with a star seen twice by Lalande in May, 1795, and which had since been listed as a fixed star No. 26266, in Lalande's catalogue. The researches which resulted in this discovery afforded the means of accurately determining the orbit of Neptune.

On August 3, 1848 (9 Stat. L., 266, 267), an appropriation of $5000 was made by Congress to be expended by the Secretary of the Navy for observations which had been recommended to him by the American Philosophical Society and the Academy of Arts and Sciences. As a result of this appropriation, an astronomical expedition in Chile, was carried on during the years 1849 to 1852, under the supervision of Lieutenant Gilliss. The results, which were published in 1854,[32] relate to Chile, its geography, climate, earthquakes, government, social condition, mineral and agricultural resources, and commerce; the solar parallax, magnetical and meteorological observations, etc.

In 1849 the first practical chronograph (Dr. John Locke's "magnetic" clock) in which electricity was first employed in the recording of observations, was installed at the observatory.

[32] 33 Cong. 1 sess., H. ex. doc. 121.

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In 1854 and 1855, important astronomical observations were made by Lieutenant John M. Brooke, in connection with the Rodgers North Pacific Exploring Expedition.[*]

Between 1854 and 1860 three minor planets were discovered at the Naval Observatory.

When Captain Gilliss succeeded Commander Maury in 1861, he continued the astronomical observations and took steps to reduce and publish the observations that had been made under the direction of his predecessor, and to have subsequent astronomical and meteorological observations published in annual volumes. Captain Gilliss died in office, February 9, 1865. With his death there passed from the Hydrographical Office and Naval Observatory the last of the four eminent scientists who had laid the foundations for these institutions; namely, Goldsborough, Wilkes, Maury, and Gilliss.

As the optical power of the telescopes at the Observatory was too low to enable the astronomers to meet the demands of the time, a new meridian circle was obtained from Pistor and Martins in Germany and was mounted on October 28, 1865. Commenting upon this new instrument, the Superintendent of the Depot said:

> The employment of this instrument in the Naval Observatory constitutes a new era in its progress and restores it to the rank of a first-class institution. The old instruments of this establishment were fully, both in size and style of their construction, up to the standard of the day in which they were ordered. But new and important advances have since been achieved in the art of making astronomical instruments, in size as well as in precision; and we find ourselves now in possession of a meridian circle with which we can measure right ascensions and polar distances at the same moment and with equal exactness.

A regular course of observations with the new instrument was begun January 1, 1866.

The astronomical and meteorological observations made during 1863 and 1864 were published during the years 1865 and 1866. An appendix to the volume of observations for 1864 discusses the latitude and longitude of the observatory. In the volume of ob-

[*] See page 19.

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servations of 1866 a full discussion is given of the meterological observations made by the observatory for the period June 30, 1842, to January 1, 1867.

Legal Status of the Depot of Charts and Instruments. The Depot of Charts and Instruments, commonly designated the Naval Observatory, had its origin in an order of the Secretary of the Navy dated December 6, 1830. It was then placed under the administrative control of the Board of Navy Commissioners, where it remained until 1842. On August 31, 1842, an act (5 Stat. L., 579) was approved which reorganized the Navy Department and abolished the Board of Navy Commissioners; and the Secretary of the Navy by order of November 26, 1842, placed the institution under the jurisdiction of the newly-created Bureau of Ordnance and Hydrography, as its hydrographic branch. Another reorganization act of July 5, 1862 (12 Stat. L., 510), replaced the Bureau of Ordnance and Hydrography, by the Bureau of Ordnance and created a new Bureau of Navigation. By order of the Secretary of the Navy, the Depot was transferred to the latter bureau on August 31, 1862, where it remained until it was replaced by the Hydrographic Office and the United States Naval Observatory September 1, 1866.

Various names have been used in legislative enactments and in official documents and correspondence to designate this institution. In official documents, the earliest mention of it was made in the executive order providing for the establishment in 1830 of a "Depot of Charts and Instruments," also designated "Depot for Charts and Instruments." These designations, however, soon became obsolete. Some letter heads used in official correspondence in October, 1844, bore the name "U. S. Naval Observatory," the earliest of such letters being dated October 12, 1844. Other letter heads used about the same time bore the name "Hydrographical Office," and still others, the name "Depot of Charts." In Volume I of Astronomical Observations for 1845, published in 1846, this institution for the first time bears the name "United States Naval Observatory," by order of the Secretary of the Navy. In December, 1854, the Secretary of the Navy directed that this institution be styled "United States Naval Observatory and Hydrographical Office," and the depot was so designated

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in the Navy Department until September 1, 1866, when the hydrographic work was separated from the Naval Observatory in accordance with the act approved June 21, 1866 (14 Stat. L., 69).

Originally known as the Depot for Charts and Instruments, the first and only legislative act designating it by that name was that of August 31, 1842 (5 Stat. L., 576), which authorized "the construction of a depot for charts and instruments of the Navy of the United States." The annual appropriation acts in which this institution was specifically mentioned, designated it variously as "Hydrographical Office," "Observatory," "National Observatory," "Naval Observatory," "Hydrographical Office and National Observatory," "Hydrographical Office and United States Observatory," "Observatory and Hydrographical Office," "United States Naval Observatory and Hydrographical Office," and "United States Observatory and Hydrographical Office." Sometimes one, sometimes two, and sometimes three of these designations were used in the same act.

The first time that the designation "Naval Observatory" was used in a legislative measure was in a paragraph of an act of August 3, 1848 (9 Stat. L., 266), making appropriation "for the pay of the Superintendent of the Naval Observatory at Washington City" and construing an item of the act of March 3, 1847 (9 Stat. L., 169), relating to the pay of the Superintendent, "to apply to the Superintendent of said Naval Observatory." The term "United States Naval Observatory," in a legislative act, was first used in an appropriation act of August 16, 1856 (11 Stat. L., 44, 47), which made provision for the "United States Naval Observatory and Hydrographical Office."

The original functions of the Depot of Charts and Instruments were to collect, verify, and correct nautical charts, books, and instruments for the use of the Navy. The original hydrographic surveys and astronomical, meteorological, and magnetic observations, were later developments.

When Congress first specifically recognized the Depot, it made no mention of its hydrographical or astronomic functions. While hydrographic surveys and exploring expeditions by the Navy Department, requiring also astronomic observations, were au-

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thorized and directed by law on several occasions prior to 1842, this Depot was not mentioned in such acts.

An act of August 3, 1848 (9 Stat. L., 268, 272), made provision "for 'meteorological observations' to be conducted under the direction of the Secretary of the Navy"; also for professors of mathematics to "perform such duties as may be assigned them by order of the Secretary of the Navy" at the "Observatory," among certain other institutions. Specific appropriations for meteorological observations were continued each year until 1859. Such observations, however, were continued after that time without specific appropriations.

Specific appropriations for "Wind and current charts" were first made in the act of August 31, 1851 (10 Stat. L., 100, 101). These appropriations were continued for each year through 1860.

Appropriations were made as follows during that period for exploring expeditions by the Navy Department, involving hydrographic, astronomic, and meteorological work: The Wilkes Exploring Expedition, to survey and explore the Pacific Ocean and the South Seas, authorized by the act of May 14, 1836 (5 Stat. L., 27, 29), which was carried on from 1838 to 1842; the Gilliss Chilean Expedition of 1848 to 1852; the Rodgers North Pacific and Arctic Surveying Expedition of 1853 to 1855; the Paraguay Expedition of 1853 to 1856; and Commodore Perry's expedition to Japan of 1852 to 1853. Subsequent appropriations were made at different times for the publication and distribution of results of these explorations and surveys.

An act approved February 21, 1861 (12 Stat. L., 147, 150), provided that "all appropriations made for the preparation or publication of foreign hydrographic surveys, shall only be applicable to their object upon the approval of the Secretary of the Navy, after a report from three competent naval officers, to the effect that the original data for the proposed charts are such as to justify their publication." It also directed the Secretary of the Navy to appoint such a board. This provision was reënacted January 12, 1895 (28 Stat. L., 601, 621), as Section 78 of "an act providing for the public printing and binding and the distribution of public documents."

Nautical Almanac Office, 1849 to 1894. In the latter part of the year 1849, the preparation of the American Ephemeris and Nautical

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Almanac was begun in Cambridge, Massachusetts, under the supervision of Lieutenant Charles H. Davis, of the United States Navy, as Superintendent, the Nautical Almanac Office being at that time directly under the Secretary of the Navy. The Nautical Almanac Office was moved from Cambridge to Washington, in July, 1866, where it was housed for some years in rented quarters. In 1883 it was removed to the State, War and Navy Building, where it remained until December, 1889, when it was removed to the Navy Yard. In 1890 it was removed to rented quarters at 1901 Pennsylvania Avenue, where it remained until removed to its present location at the Naval Observatory on October 20, 1893.

The first volume of the American Ephemeris and Nautical Almanac, for the year 1855, was published late in 1852 at Cambridge.

Authority for the preparation and publication of the Nautical Almanac was given in an appropriation act of March 3, 1849 (9 Stat. L., 374, 375), which provided "That a competent officer of the Navy not below the grade of lieutenant, be charged with the duty of preparing the nautical almanac for publication and that the Secretary of the Navy may when, in his opinion, the interests of navigation would be promoted thereby, cause any nautical work that may, from time to time, be published by the hydrographical office, to be sold at cost, and the proceeds arising therefrom to be placed in the treasury of the United States." Although this provision was part of a paragraph relating to the Hydrographical Office it was not construed as placing this work of preparing the nautical almanac under that institution. It was, therefore, originally published by a separate office. Annual provision has been made for this publication, and the Nautical Almanac Office is now a part of the Naval Observatory.[34]

The appropriation for the Nautical Almanac for the fiscal year ending 1851, in the act of September 28, 1850 (9 Stat. L., 513, 515), had a proviso, "That hereafter the meridian of the observatory at Washington shall be adopted and used as the American meridian for all astronomical purposes, and that the meridian of Greenwich shall be adopted for all nautical purposes.' This

[34] See page 80.

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proviso was repealed by the act of August 22, 1912 (27 Stat. L., 328, 342).

An act of August 5, 1854 (10 Stat. L., 583), provided that "any naval officer who may be charged with the preparation, superintendence, or publication of the Nautical Almanac shall receive no compensation for such duty beyond what he would receive while on duty at sea." An act of March 3, 1857 (11 Stat. L., 243, 246), authorized the Secretary of the Navy to "place the supervision of the Nautical Almanac in charge of any officer or professor of mathematics in the Navy who is competent for that service." Until 1858, the American Nautical Almanac was issued by an independent service of the Navy Department, the head of which reported direct to the Secretary of the Navy. After that, the Nautical Almanac Office, still a separate unit, was placed under the same bureau control as the Depot of Charts and Instruments and its successors, the Hydrographic Office and the Naval Observatory.[35]

In 1882 the Nautical Almanac Office issued the first volume of the Astronomical Papers of the American Ephemeris, a series of papers which have since appeared at irregular intervals.[36]

On September 20, 1894, the Secretary of the Navy, availing himself of the authority granted in the act of March 3, 1857,[37] issued a regulation making the Nautical Almanac Office a branch of the Naval Observatory. In a departmental decision rendered January 19, 1905 (File 9449-04 and 17626 Navy Department), it was held that the Nautical Almanac Office is not a separate shore station, and since that time its status has been that of a department of the Naval Observatory.

The Naval Observatory, 1866 to 1926. In 1866 there were included in one organization, a depot of charts and instruments, a hydrographic office, and an astronomical, a meteorological, and a magnetic observatory, all under the Superintendent of the Naval Observatory, who in that year, by a resolution of the Senate, was also required to make a report on interoceanic canals and railroads. As the functions of these institutions were regarded as too diverse for one organization, a separation was made in that year.

[35] See page 29.
[36] See page 73.
[37] See page 80.

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An act of Congress approved June 21, 1866 (14 Stat. L., 69), entitled "An Act to Establish a Hydrographic Office in the Navy Department," defines the functions of that Office, and constitutes the organic act of that institution as it exists today. It virtually separated that Office from the United States Naval Observatory, although the latter was not mentioned in the act. The separation actually took place September 1, 1866, when Lieutenant Commander T. S. Fillebrown was detached from the Naval Observatory, where he had charge of preparation of charts, etc., and was appointed Hydrographer of the newly-created Hydrographic Office.

There remained, therefore, for the Naval Observatory those functions of an astronomical character, including the rating of chronometers and the care of navigational and surveying instruments which had previously been exercised by the Depot of Charts and Instruments, and which were not transferred by that act. These functions were continued with the personnel which remained after the transfer of the persons who had been assigned to the Hydrographic Office. The Observatory continued to function as a separate office in the quarters built for the Depot of Charts and Instruments in 1844. By a decision of the Secretary of the Navy, rendered May 26, 1914, the Naval Observatory was ranked as a naval station, and the Superintendent as the commandant of a naval station.

Administration and Equipment. At the time of the separation of the Hydrographic Office from the Naval Observatory, both institutions were attached to the Bureau of Navigation of the Navy Department. On July 1, 1889, the Naval Observatory was attached to the Bureau of Equipment. An act of June 24, 1910 (36 Stat. L., 605, 613), having provided for the abolition of the Bureau of Equipment, the Naval Observatory was retransferred by order of the Secretary of the Navy, dated June 27, 1910, to the Bureau of Navigation, on July 1, 1910, where it has since remained.

In 1873 the Naval Observatory began observations with what was at that time the largest refractor in the world. Although effective work had been accomplished by the Naval Observatory prior to that time with its nine-inch equatorial, this instrument had become inadequate and antiquated, so that the Superinten-

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dent found it necessary in his annual report for 1868 to call attention to that fact. He recommended the employment of Alvan Clark of Cambridgeport, Massachusetts, to construct the largest refractor in the world as a fitting instrument for the Naval Observatory. He repeated this recommendation the following year and submitted an estimate of $50,000 as the cost of procuring the refractor.

This recommendation was adopted by Congress, the naval appropriation act of July 15, 1870 (16 Stat. L., 321, 334), providing in Section 18, "That the Superintendent of the Naval Observatory be, and he is hereby, authorized to contract for the construction of a refracting telescope of the largest size, of American manufacture, at a cost not exceeding fifty thousand dollars." A subsequent act made appropriation for the erection of a tower and dome for the housing of this instrument.

By the terms of the contract made with Alvan Clark and Sons of Cambridgeport, Massachusetts, in August, 1870, that firm was required "to construct a refracting telescope, of good definition and of twenty-six inches clear aperture, mounted equatoreally [*sic*] on the German plan, with all the usual and necessary counterpoises and other devices to secure easy motion, its proper balance in all positions, and the safety of its object-glass; with divided circles to be each read by two microscopes—the R. A. [right ascension] circle to seconds, and the declination circle to tenths of a minute of arc—with a driving clock, . . . and with the usual number . . . of eye-pieces, and ring-micrometers, . . . and a spectroscope. . . ."[38] Clark and Sons engaged to complete and mount this telescope within four years from the date of the contract.

The object-glass was made in the rough in England, was received by Clark and Sons in December, 1871, and was ground, polished, and completed in November, 1872. It was set in place in 1873, and the first observations were made on November 20, 1873.

In 1881, the Government selected the site where the Naval Observatory is now located. An act of February 4, 1880 (21 Stat.

[38] Original contract at Naval Observatory.

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THE UNITED STATES NAVAL OBSERVATORY.

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L,. 64), provided for the appointment of a commission consisting of a Senator, a Representative, and the Superintendent of the Naval Observatory, "to select a site for a new Naval Observatory, the said site to be, if practicable, upon an even degree of longitude west of Greenwich, and to possess the relative advantages of facility of access from the City of Washington, healthfulness, clearness of atmosphere, freedom from obstruction for the horizon, and freedom from objectionable vibrations from traffic or other causes, with ability to have sufficient water supply."

On March 8, 1881, a large tract of land was acquired on Georgetown Heights bordering what is now Massachusetts Avenue, N. W. A remaining tract of seven acres is needed to complete a circle with a radius of 1000 feet from the clock room.[29]

The site selected possesses the qualifications called for in the act in as great a degree as any which could possibly have been found within the District of Columbia. An act of July 26, 1886 (24 Stat. L., 149, 156), appropriated $50,000 "for commencing the erection of a new Naval Observatory," with the proviso "That the construction of no building shall be commenced except an observatory proper, with necessary offices for observers and computers." Further appropriations of $50,000 for continuing, and $240,000 for completing, the erection of the observatory and necessary buildings were made by the acts of September 7, 1888 (25 Stat. L., 458, 463), and March 2, 1889 (25 Stat. L., 809, 814), respectively. It was not until May 15, 1893, however, that the new site was formally occupied by the Naval Observatory. This site of about seventy-two acres is kept as a public park with funds appropriated for the Naval Observatory. The Nautical Almanac Office was removed there on October 20, 1893.

At the time of the removal, the new buildings comprised a commodious office building occupied by the astronomical, nautical instrument, time service, and nautical almanac departments. The twenty-six inch equatorial, a nine-inch and a six-inch transit circle, and a five-inch prime vertical instrument, were placed in suitable domes and houses to the south, east, west, and north of the clock house, the longitude of which is 5h. 8m. 15.78s. west

[29] See page 81.

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and the latitude 38° 55′ 14″.0 north. The altitude above sea-level is 280 feet. Besides the above-mentioned instruments, there are now a twelve-inch equatorial, a five-inch alt-azimuth, a five-inch transit, a five-inch photoheliograph, a photographic equatorial with two triple ten-inch lenses, and an eight-inch photographic zenith-tube.[40] Although one of the youngest among the great astronomical institutions, it had by that time, 1893, developed to a rank equal with those at Greenwich and Pulkowa.

In order that the delicate astronomical instruments at the Naval Observatory might be guarded against vibrations from traffic and other disturbances, a joint resolution was adopted August 1, 1894 (28 Stat. L., 588), "That no street, avenue, or public thoroughfare in the neighborhood of the buildings erected upon the United States Naval Observatory grounds, Georgetown Heights, District of Columbia, shall extend within the area of a circle described with a radius of 1000 feet from the center of the building known as the clock room of the said Observatory." In the planning of the city streets since that time, cognizance has been taken of that enactment.

On April 12, 1892, a joint resolution was adopted (27 Stat. L., 395) providing that the "facilities for research and illustration" of certain governmental collections established in the City of Washington for the promotion of knowledge shall be made accessible to the scientific investigators and to students of institutions of higher education incorporated under the laws of Congress or of the District of Columbia. The Naval Observatory is one of twelve government institutions mentioned in the resolution. An act of March 3, 1901 (31 Stat. L., 1010, 1039), provides for such access in more general terms.

On June 30, 1899, a Board of Visitors appointed by the Secretary of the Navy, met at the Naval Observatory and recommended the creation of a permanent Board of Visitors to the Naval Observatory to be appointed by the President. Accordingly, provision was made for such a Board in an act approved March 3, 1901 (31 Stat. L., 1107, 1122). This Board consisted of six civilians, four of whom must be "astronomers of high professional standing" and two "eminent citizens," appointed for periods of three

[40] See Appendix 4.

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years, by the President, by and with the advice and consent of the Senate. The members received no compensation for their services, but actual expenses incurred in the discharge of their duties were reimbursed. Their functions were to "make an annual visitation to the Observatory at a date to be determined by the Secretary of the Navy, and make such other visitations not exceeding two in number annually . . . as may be deemed needful or expedient by a majority of the Board," and to report to the Secretary of the Navy at least once each year the results of its examinations "as respects the condition of buildings, instruments, and apparatus and the efficiency with which its scientific work is prosecuted," and "as respects the expenditures in the administration of the Observatory;" also to "prepare and submit to the Secretary of the Navy regulations prescribing the scope of the astronomical and other researches of the Observatory and the duties of its staff with reference thereto." The act also provided that the Board of Visitors may by a majority vote make recommendations to the Secretary of the Navy, of suitable persons to fill the office of Astronomical Director, Director of the Nautical Almanac, Astronomer or Assistant Astronomer, whenever an appointment or detail is to be made. No appropriation having been made for its maintenance since that year, the Board of Visitors was discontinued after the fiscal year 1902.

The same act provides that the Superintendent of the Naval Observatory shall be a line officer of the Navy of a rank not below that of captain.

In 1904, a small branch observatory was established in Tutuila, American Samoa, for astronomical and magnetic observations in the southern hemisphere, but it was abandoned in May, 1908, on account of climatic and terrestrial conditions.

On November 17, 1913, work was begun in a nautical instrument repair shop, which was established at the Naval Observatory. Nearly all the repairs to nautical and surveying instruments used in the Navy have since been made there.

In October, 1917, an "Aviation Section" of the Naval Observatory was established for the purpose of simplifying and facilitating the Observatory's work with regard to the design, procurement, and issue of aeronautical instruments, and their development and standardization.

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Time Service. In August, 1865, the Naval Observatory began sending time signals from the chronometer room daily at 7 a. m., 12 m. and 6 p. m. to the fire-alarm and police stations of Washington, D. C.; and at 12 m. to the Western Union Telegraph Company for communication to the offices of the company's lines throughout the United States. The latter was the beginning of the present elaborate system for the distribution of "Naval Observatory Time, Hourly by the Western Union." Since May, 1877, the Western Union has been furnishing the Naval Observatory time to all cities of over 20,000 population in the United States. This privilege of obtaining Naval Observatory time was extended not only to the Western Union, but also to all other companies willing to extend lines to the Naval Observatory, as was done by the Western Union at its own expense. Two other companies have availed themselves of this privilege.

The dropping of a time-ball on the roof of the Naval Observatory daily at noon was begun some time in the early forties, the exact time being unknown.[41] This time-ball was removed to the roof of the State, War, and Navy Building on July 11, 1885, when the Naval Observatory time-ball was discontinued, and it is being dropped there every day at noon.

In 1880, the Naval Observatory began the sending of the time signals automatically instead of by hand, by the application of a device invented by an employee of the Observatory. Three years later, clocks automatically controlled by this device and actuated by the Naval Observatory clock, were in use in most of the government departments.

A new system of time reckoning was inaugurated on all the principal railroads of the United States at noon on November 18, 1883, whereby the continent was divided into five longitudinal belts, and a meridian of time is fixed for each belt. These meridians begin with the 60th meridian west of Greenwich and approximately are fifteen degrees of longitude, or one hour's time apart. By this means the time standards of railroads were reduced from fifty-three to five for the entire country. These standards have since been adopted locally throughout the United States. Begin-

[41] A picture of the Naval Observatory made in 1845 shows the time-ball, and official correspondence shows that new time-balls were requested in 1849.

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ning March 1, 1884, the time-ball on the State, War and Navy Building was dropped at 75th meridian time.

This new system of standard time was suggested by a committee on the American Metrological Society appointed at the request of Professor Cleveland Abbe of the Signal Service of the United States Army (Weather Bureau), of which committee he was chairman. The report of the committee was published in May, 1879, and it was largely through the efforts of W. F. Allen, Secretary of the General Time Convention of Railroad Officials, that the new system was adopted by the railroads. While Professor Abbe suggested the appointment of this committee in May, 1875, others, including Professor Charles F. Dowd, Sanford Flemming and W. F. Allen, had also thought along similar lines.[42]

In 1884, a Chronometer and Time Station was established and a small observatory was built at the Navy Yard at Mare Island, California, for the purpose of furnishing time to the West Coast.

In 1889 time-balls were installed at Boston, Woods Hole, Newport, New York, Philadelphia, Baltimore, Hampton Roads, Savannah, and New Orleans. One was installed at Pittsburgh on March 11, 1905.

Before July 1, 1902, the Naval Observatory signals were sent for a period of three minutes and fifteen seconds, but since that date the periods have been for five minutes.

In 1902 the chronometer room at the Naval Station at Cavite, Philippine Islands, was connected by wire with the Manila Observatory, which has been furnishing the time daily since the beginning of April, 1903. In that year a Reifler clock was installed at the station and in September, 1905, a time-ball.

On August 9, 1904, the first time signal by radio, was sent from the station at the Navy Yard at Boston, and by the end of that year the naval stations at Cape Cod and Norfolk were also sending the signals, the range to be relied upon at that time being about fifty miles. In January, 1905, the Naval Observatory at Washington began the practice of regularly transmitting time signals by radio telegraphy from the Navy Yard, Washington, D. C., with the idea of reaching ships as far at sea as possible. The Naval Observatory was the first institution in the world to engage in this undertaking, having preceded by two years, that of any other

[42] "*Science*," September 8, 1905, p. 316.

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nation. At present, owing to the existence of a network of high power naval radio stations, the time signals from the Naval Observatory at Washington can be heard all over the world.

By 1909 the number of stations sending radio time signals had been increased to nineteen, and the range to one hundred miles. As the range increased, the number of stations was reduced until, with the establishment of the high power station at Arlington, in 1913, with a range of 3000 miles, the only other stations sending the time on the East Coast of the United States were Key West, Florida, and New Orleans.

On March 31, 1913, the Arlington station began sending a night signal by radio during the five-minute interval from 9.55 p. m. to 10.00 p. m. Since then that station has been sending every day, including Sundays and holidays, noon and 10 p. m. signals received from the Naval Observatory. On July 1, 1913, the Time Station at Mare Island, California, began the 10 p. m. (120th meridian) time signal.

The number of sending stations (using different wave lengths) has been increased from time to time to supply the growing demand, so that in 1925, thirteen naval radio stations on the coasts and in Panama, Hawaii, and the Philippines, were sending radio time signals.

During the World War the time service of the Naval Observatory, in coöperation with the radio stations of the Navy Department, rendered a most valuable service. Many vessels had to be sent to sea with rather ordinary time-pieces, because there were not enough good chronometers at hand to supply all the vessels. The daily radio time signals, therefore, had to be depended upon for the accurate determination of the vessel's position. The signals went out by Navy radio and land lines without intermission, and all other radio work was stopped while the time signals were being sent. The accuracy of the time and of the navigating instruments furnished by the Naval Observatory to vessels of the Navy, enabled the destroyers to meet and to convoy cargoes during the war with such certainty that there never was a failure to meet at the rendezvous in any kind of weather.

Astronomical Day. On January 1, 1925, a change was made in the Nautical Almanac by which the astronomical day started at midnight instead of at noon. This change had been unanimously

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recommended at an International Conference on Time in 1884. It was not until after another international agreement in 1919, and after consultation with the navigators of the Navy and a majority of the merchant marine, that the change was authorized. The change was made by all national almanacs, and it relieved astronomers and navigators of the necessity of using two different day periods, the astronomical day, beginning at noon, and the civil day, beginning at midnight.

Longitude Determination by Telegraph and Radio. The telegraph was first used for ascertaining differences in longitude in 1842, when Captain Wilkes determined the difference in longitude between Washington and Baltimore. As early as 1847, the Naval Observatory began coöperating with the Coast Survey in making such determinations and this coöperation has continued to the present time.

The Naval Observatory, with the coöperation of the Western Union Telegraph Company, undertook in 1868 and 1869 the determination of longitudes by means of the telegraph, of stations in Havana, Des Moines, and Bristol, Tennessee. It also exchanged time signals with an observing party of the Coast Survey at Staunton, Virginia, on April 7, 1869. In 1871, at the request of the Chief of Engineers of the Army, the Observatory aided in determining differences of longitude between the Observatory and Detroit, and the Observatory and Carlin and Austin, Nevada. In July and August, 1872, the Naval Observatory again coöperated with the Coast Survey, by exchanging longitude signals with Survey parties at Cambridge, and at St. Pierre, near Newfoundland, at the same time when time signals were being exchanged between St. Pierre and Brest, France, and between Brest and Paris and Greenwich, England.

At the International Conference held in Paris, France, in October, 1912, a letter from the Superintendent of the United States Naval Observatory was read in which he suggested a determination of the difference of longitude between the Naval Observatory at Washington and the Observatory at Paris, by means of radio time signals. This was done in 1913 and 1914, the Naval radio station at Arlington, and the Eiffel Tower radio station at Paris, France, having been used as the means of communication. These

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observations constitute the first direct determination of the difference of longitude and of the velocity of transmissions of radio waves between the United States and Europe, and it was the first time that radio has been used for transatlantic longitude determinations.[43]

The Special Swiss Commission to determine the boundary between Colombia and Venezuela, used the Naval Observatory radio time signals in 1923 to 1925.

The most recent work of this character was done in 1925, when the Naval Radio Station at San Diego, California, sent special time signals for use by the Coast and Geodetic Survey in the Western Aleutian Islands, these signals being recorded there and at the Naval Observatory where the errors were determined. These signals were also used in Canada, Australia, New Zealand, and Mexico. At present, radio time signals are being used by naval surveying parties in the Caribbean Sea, the observers having been previously instructed at the Naval Observatory.

Astronomical Observations. The principal astronomical work of the Observatory has continued to be the making of observations of the sun, moon, planets and brighter stars.

Special astronomical work has been undertaken from time to time. An act of March 1, 1869 (15 Stat. L., 276, 278), appropriated $5000 for observation of the total eclipse of the sun on August 7, 1869, to be made under the direction of the Superintendent of the Nautical Almanac. Observing parties were sent to Alaska, Illinois, Iowa, Missouri, and Tennessee.[44]

Another appropriation of $29,000 was made July 15 of the following year (16 Stat. L., 291, 308), "to enable the Superintendent of the Coast Survey to make observations in Europe" on the eclipse of December 22, 1870. Representatives of the Naval Observatory participated in observations made at Gibraltar and in Sicily.[45]

[43] The results of that wireless longitude determination and the determination of the velocity of transmission of the radio waves have been published in Naval Observatory Publications Vol. IX. Appx. I, second series.

[44] The results of these observations were published in Washington Observations, 1867, Appendix II, Washington, 1870.

[45] The results of these observations were published in Washington Observations, 1869, Appendix I, Washington, 1872.

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Preparations for the observations of the Transit of Venus on December 8-9, 1874, were begun early in 1871, an appropriation of $20,000 having been made on March 3, 1871 (16 Stat. L., 526, 529), "for preparing instruments for observation of Transit of Venus." The same act provided for the appointment of a commission to be composed of the Superintendent and two of the professors of mathematics attached to the Naval Observatory, the President of the National Academy of Sciences, and the Superintendent of the Coast Survey, under whose direction "this and all other appropriations made for the observations of the Transit of Venus shall be expended." This commission made an estimate of $150,000, and Congress responded by appropriating $50,000 on June 10, 1872 (17 Stat. L., 347, 367), and $100,000 on March 3, 1873 (17 Stat. L., 510, 514). Accordingly, observations were made of the Transit of Venus in 1874 by the Naval Observatory representatives, and two vessels of the Navy were employed in conjunction with vessels of England, France, Germany, and Russia in transporting parties for making observations elsewhere, the United States parties making observations in Siberia, Kerguelen, and Tasmania. The results of these observations were published in 1880.

In August, 1877, Professor Asaph Hall of the Naval Observatory discovered the two satellites of Mars with the twenty-six-inch refractor.

Parties from the Naval Observatory made observations of the total eclipse of the sun on July 29, 1878, in Wyoming, Colorado, and Texas, an appropriation of $8000 for this purpose having been made in the act of April 30, 1878 (20 Stat. L., 41, 45). On January 11, 1880, observations of another solar eclipse were made in California.[46]

An act of March 6, 1882 (22 Stat. L., 7, 8), appropriated $10,000 "for the repair and purchase of instruments to be used in observing the Transit of Venus" December 6, 1882, and for the necessary preliminary experiments. The act made the Superintendent of the Nautical Almanac an additional member of the Transit of Venus Commission, created by the act of March 3, 1872, which was entrusted with the incurring of this expendi-

[46] The results of observations of both eclipses were published in Washington Observations, 1876, Appendix III, Washington, 1880.

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ture. A further appropriation of $25,000 for this purpose was made by the act of August 7, 1882 (22 Stat. L., 302, 323), and an appropriation of $5000 for completing reductions of these observations, was made by the act of July 7, 1884 (23 Stat. L., 159, 184). Expeditions were sent to Florida, Texas, Chile, Patagonia, and South Africa, to make these observations.[47]

Under date of May 10, 1887, Dr. Arthur Auwers, President of the Astronomische Gesellschaft, of Leipzig, Germany, extended an invitation to the Naval Observatory to participate in observations of stars to the ninth magnitude in the zones $-2°$ to $-23°$. This invitation was accepted.[48]

An expedition under the auspices of the Navy Department, was sent to the West Coast of Africa to observe the total eclipse of the sun which occurred December 22, 1889, but clouds prevented observations of the total phase.[49]

On May 28, 1900, and on May 17, 1901, the Naval Observatory observed total eclipses of the sun, for which work appropriations of $5000 and $10,000 respectively, had been made in acts approved February 9, 1900 (31 Stat. L., 7, 19), and January 4, 1901 (31 Stat. L., 727, 728). For the first mentioned eclipse, observing stations were established at Pinehurst, North Carolina, and Barnesville and Experiment Station (Griffin), Georgia, and for the other in Sumatra.[50]

During the period, 1903 to 1923, six minor planets were discovered at the Naval Observatory.

[47] The resulting values of the solar parallax obtained from the observations of the Transits of Venus of 1874 and 1882 are given in Washington Observations, 1885; Appendix III, p. 53, 1891.

[48] The results of these observations were published in Naval Observatory Publications, Second Series, Volume II, 1902.

[49] On December 22, 1888 (25 Stat. L., 638), an appropriation of $5000 was made by Congress to be expended by the Secretary of the Navy for observing an eclipse of the sun, which occurred January 1, 1889. The enactment was too late to make the money available in time for the eclipse, so Congress reappropriated the amount on March 2, 1889 (25 Stat. L., 905, 920), to defray the expenses of an expedition to the West Coast of Africa to observe a total eclipse of the sun which occurred December 22, 1889. This work, however, was not carried on by the Naval Observatory.

[50] The results of the observations of both these eclipses were published in Naval Observatory Publications, Second Series, Volume IV, Part IV, Appendix I, 1906. A report of the eclipse of May 28, 1900, is also given in The American Ephemeris, 1900 Supplement.

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A squadron of three naval vessels was sent out under the Superintendent of the Naval Observatory to make observations of a total eclipse of the sun of August 30, 1905, at observation stations which it established at Daroca and Porta Coeli, Spain, and Guelma, Algeria. An appropriation of $5000 for this work was made by the act of February 3, 1905 (33 Stat. L., 631, 666).[51]

An act of March 3, 1917 (39 Stat. L., 1070, 1100), appropriated $3500 "for expenses in preparing for and conducting observations of the total solar eclipse of June 8, 1918, to be expended by the Naval Observatory. Observations were made at Baker City, Oregon.

On April 10, 1924, the Naval Observatory issued a circular calling attention to the Transit of Mercury of May 7, 1924. A considerable number of observations of the contact times have been forwarded to the Observatory and have been prepared for publication. Many were prevented from making such observations on account of cloudy weather.

On January 24, 1925, a party from the Naval Observatory, under the Superintendent, observed successfully, for the first time in history, a total solar eclipse from an airship. At the request of the Naval Observatory the use of the giant naval airship, "Los Angeles," and the coöperation of the Bureau of Aeronautics were obtained for this purpose. The observations were taken over the Atlantic Ocean east of Long Island at an altitude of 4500 feet.[52]

On February 11, 1925 (43 Stat. L., 861, 869), an appropriation of $3670 was made to defray expenses "in preparing for and conducting observations of total solar eclipse of January 14, 1926." A party from the Naval Observatory observed this eclipse in Sumatra.

International Conferences. On August 3, 1882 (22 Stat. L., 217), a joint resolution was adopted by Congress authorizing the President to call an international conference to fix on and recommend for universal adoption, a common prime meridian to be used in the reckoning of longitude and in the regulation of time

[51] The results of these observations were published in Naval Observatory Publications, Second Series, Volume X, Part II, Appendix, 1925.

[52] The results of these observations have not yet been officially published, but articles by members of the party have appeared in current astronomical literature. See page 75.

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throughout the world. Accordingly, invitations for such a conference were addressed to foreign governments by the Secretary of State. At the request of the President, Congress on July 4, 1884 (23 Stat. L., 194), appropriated $5000 for the expenses of the conference. The conference which met in Washington in October and concluded its labors on November 1, 1884, consisted of representatives of twenty-five nations. It agreed "with substantial unanimity" upon "the meridian of Greenwich as the starting point whence longitude is to be computed through 180 degrees eastward and westward, and upon the adoption, for all purpose for which it may be found convenient, of a universal day which shall begin at midnight on the initial meridian and whose hours shall be counted from zero to twenty-four."[53]

At the Conférence Internationale des Étoiles Fondamentales held in Paris in May 1896, the Naval Observatory was represented by the Director of the Nautical Almanac. At that conference values of solar parallax, the constant of nutation, and the constant of aberration were agreed upon for international use, and the Director of the Nautical Almanac was requested to complete the catalog of stars then in preparation by him, in a form suitable for international use in astronomical ephemerides generally.[54]

The director of the Nautical Almanac represented the Naval Observatory at the *Congrès International des Éphémérides Astronomiques* held at the Observatory of Paris October 23 to 26, 1911. This Congress recommended the adoption of exchanges of data, and, in a resolution, it expressed the wish "that the adoption of the meridian of Greenwich for all ephemerides be realized as soon as possible." Compliance with this resolution was made possible by the act of August 22, 1912 (37 Stat. L., 328, 342), repealing the provision of the act of September 29, 1850 (9 Stat. L. 513, 515), which directed that "the meridian of the Observatory at Washington shall be adopted and used as the American meridian for all astronomical purposes."

The same act authorized the Secretary of the Navy to arrange for the exchange of data with foreign almanac offices "with a

[53] Message of President Arthur, December 1, 1884. See also his special message of December 4.

[54] The resulting catalog was published in Astronomical Papers of the American Ephemerides, Vol. VIII, Part II, 1914.

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view of reducing the amount of duplication of work in preparing the different national nautical and astronomical almanacs and increasing the total data which may be of use to navigators and astronomers available for publication in the American Ephemeris and Nautical Almanac." There is a provision in the act "that the work of the Nautical Almanac Office during continuance of any such arrangement shall be conducted so that in case of any emergency, the entire portion of the work intended for the use of navigators may be computed by the force at that office without any foreign coöperation whatever." This provision was carried out during the World War, when there was no interruption in the preparation and publication of the American Ephemeris and Nautical Almanac. Another provision requires "that employees of the Nautical Almanac Office whose services can be spared from the duty of preparing the annual volumes of the American Ephemeris and Nautical Almanac may be employed by that office in the work of improving the tables of planets, moon and stars, to be used in preparing for publication the annual volumes of the office."

In accordance with this authority the Naval Observatory agreed to adopt the program of exchange of data recommended by the International Conference, with the understanding that the proposed agreement may be terminated on one year's notice, and with certain other reservations.

With regard to the meridian of Greenwich the Naval Observatory accepted the resolution of the Conference in spirit, but reserved the right to publish certain ephemerides for the meridian of Washington. As a result of this resolution and the repeal of the above mentioned provision of the act of September 29, 1850, the following changes were made, among others, in the American Ephemeris and Nautical Almanac beginning with the edition of 1916. In the elements for the prediction of occultations, the time of conjunction in right ascension is given in Greenwich time. Greenwich time is also used in the ephemerides for the physical observations of the sun, moon, and planets, and in the satellite data, and in the published phenomena.

The International Congress of October, 1911, adopted the list of stars of the Astronomical Papers of the American Ephemeris, volume VIII, part 3, for the predictions of occultations, and prescribed the tables of Newcomb and Hill for calculations of

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positions of the sun and planets for all the ephemerides except the calculations made by the "*Connaissance des Temps.*"

Executive Heads of the Naval Observatory and Nautical Almanac Office. Following is a list of officers in charge of the Depot of Charts and Instruments, superintendents of the United States Naval Observatory, and superintendents of the Nautical Almanac Office and directors of the Nautical Almanac, from the beginning of these institutions to the present time, with the dates of commencement and termination of service of each:

OFFICERS IN CHARGE OF THE DEPOT OF CHARTS AND INSTRUMENTS

Lieutenant L. M. Goldsborough	Dec. 6, 1830–Feb. 11, 1833
Lieutenant Charles Wilkes	Mar. 12, 1833–June 14, 1837
Lieutenant James Melville Gilliss	June 14, 1837–July 11, 1842
Lieutenant Matthew Fontaine Maury	July 11, 1842–Oct. 1, 1844

SUPERINTENDENTS OF THE NAVAL OBSERVATORY

Commander Matthew Fontaine Maury[55]	Oct. 1, 1844–Apr. 20, 1861
Captain James Melville Gilliss	Apr. 23, 1861–Feb. 9, 1865
Rear Admiral Charles Henry Davis	May 11, 1865–May 15, 1867
Rear Admiral Benjamin F. Sands	May 15, 1867–Feb. 23, 1874
Rear Admiral Charles Henry Davis	Feb. 23, 1874–Feb. 18, 1877
Rear Admiral John Rodgers	May 1, 1877–May 5, 1882
Vice Admiral Stephen C. Rowan	July 1, 1882–May 1, 1883
Rear Admiral Robert W. Shufeldt	May 1, 1883–Feb. 21, 1884
Rear Admiral Samuel R. Franklin	Feb. 21, 1884–Mar. 31, 1885
Commodore George E. Belknap	June 1, 1885–June 7, 1886
Captain Robert L. Phythian	Nov. 15, 1886–June 28, 1890
Captain Frederick V. McNair	June 28, 1890–Nov. 21, 1894
Commodore Robert L. Phythian	Nov. 21, 1894–July 19, 1897
Captain Charles Henry Davis, 2d	July 19, 1897–Apr. 16, 1898
Commodore Robert L. Phythian (ret.)	May 18, 1898–Nov. 1, 1898
Captain Charles Henry Davis, 2d	Nov. 1, 1898–Nov. 1, 1902
Rear Admiral Colby M. Chester	Nov. 1, 1902–Feb. 28, 1906
Rear Admiral Asa Walker	Feb. 28, 1906–Nov. 13, 1907
Rear Admiral William J. Barnette	Dec. 2, 1907–Apr. 19, 1909
Commodore T. E. D. W. Veeder	Apr. 20, 1909–Oct. 16, 1911
Captain Joseph L. Jayne	Oct. 16, 1911–Feb. 11, 1914
Captain John A. Hoogewerff	Feb. 11, 1914–Mar. 31, 1917
Rear Admiral Thomas B. Howard (ret.)	Mar. 31, 1917–Mar. 4, 1919
Rear Admiral John A. Hoogewerff	Mar. 4, 1919–June 8, 1921
Rear Admiral Wm. D MacDougall	Aug. 1, 1921–Oct. 5, 1923
Captain Edwin T. Pollock	Oct. 5, 1923–

[55] Promoted to Commander September 14, 1855.

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SUPERINTENDENTS OF THE NAUTICAL ALMANAC OFFICE

Lieutenant Charles Henry Davis[56]	July 11, 1849 (ordered)–Nov. 23, 1856
Professor Joseph Winlock	Nov. 23, 1856–Aug. 9 or 10, 1859
Commander Charles Henry Davis	Aug. 10, 1859–Sept. 18, 1861
Professor Joseph Winlock	Sept. 18, 1861–May 1, 1866
Professor John H. C. Coffin	May 1, 1866–Sept. 15, 1877
Professor Simon Newcomb	Sept. 15, 1877–Sept. 20, 1894

DIRECTORS,[57] NAUTICAL ALMANAC

Professor Simon Newcomb	Sept. 20, 1894–Mar. 12, 1897
Professor William W. Hendrickson	Mar. 12, 1897–June 30, 1897
Professor William Harkness	June 30, 1897–Dec. 15, 1899
Professor Henry D. Todd	Dec. 15, 1899–Aug. 24, 1900
Professor Stimson J. Brown	Aug. 24, 1900–Mar. 25, 1901
Professor Walter S. Harshman	Mar. 28, 1901–Oct. 1, 1907
Professor Milton Updegraff	Oct. 1, 1907–Nov. 2, 1910
Captain William S. Eichelberger	Nov. 2, 1910–

[56] Promoted to Commander in 1854.

[57] Title changed from "Superintendent, Nautical Almanac Office" to "Director, Nautical Almanac," September 20, 1894.

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CHAPTER II

ACTIVITIES

The functions of the Naval Observatory consist of:[1] (a) Furnishing daily time signals by radio and telegraph; (b) maintaining continuously observations of the heavenly bodies for improving the tables of the planets, moon, satellites and stars, and for determining the fundamental astronomical constants used in preparing the American Ephemeris and Nautical Almanac and making observations for determining the time; (c) computing and preparing for publication the American Ephemeris and Nautical Almanac and improving the tables used in preparing that work; (d) developing, supplying, keeping up, repairing, and inspecting navigational and aeronautical instruments for the Navy, and to some extent for the Shipping Board.

The Naval Observatory is the principal source of supply in the United States of data required for navigational astronomy, and it establishes the standard time for the entire country and the adjacent oceans.

There is no organic act defining the duties and functions of the Naval Observatory or any of its departments. The duties now performed concerning the care and custody of instruments and the rating of chronometers were first directed by an order of the Secretary of the Navy dated December 6, 1830. The first statute relating to the Nautical Almanac was the act of March 3, 1849 (9 Stat. L., 375), providing for the appointment of a competent officer with the duty of preparing it for publication. Other acts relating to personnel and publications and making appropriation for specific astronomic and other work have been enacted from time to time, and are considered in the preceding chapter, especially in the subchapter on "Legal Status of the Depot of Charts and Instruments."

[1] Office of Naval Intelligence, The United States Navy as an Industrial Asset (Revised to July 1, 1924), p. 29.

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The following order of the Superintendent, dated July 29, 1908, gives an outline of the functions of the Naval Observatory.

There is hereby formed an astronomical council composed of the following members: The Superintendent *(ex officio)*, the Assistant Superintendent, such assistants in charge of the astronomical divisions as the Superintendent may designate, and the Director of the Nautical Almanac.

The council should be guided by the fact that the most important astronomical duty of the Government is the publication of the Nautical Almanac, and as that is intended not only for the use of navigators, but also of astronomers in the most delicate investigations known to their science, it should be kept up to the highest attainable pitch of accuracy. To that end, continuous fundamental meridian observations upon the sun, moon, planets, and stars, are absolutely necessary and constitute the astronomical essentials.

The council shall advise the Superintendent on the following subjects:

1. The coördination and coöperation of the work of the Department of Astronomical Observations and of the Nautical Almanac Office.
2. Suggested variations from the plan of astronomical work prescribed by the regulations.
3. Methods to be used in the prosecution of the astronomical work.
4. Condition of and charges proposed in instrumental equipment.
5. The assignment of the scientific personnel to give the best possible results. The assignment of computers should be so made as to balance the work of the observers and the computers, in order that observations may be expeditiously published.
6. The character and astronomical value of the observations and their publications.
7. Promotions, transfers, and filling of vacancies.
8. The yearly estimates for submission to the Secretary of the Navy.
9. The expenditure of the appropriations for astronomical and scientific purposes.
10. A system by which the cost of any piece of work may be readily available.

Of the above-mentioned subjects, those relating to the Nautical Almanac Office shall be considered first by the director of that office, those relating to the Department of Astronomical Observations shall be considered first by an executive committee, and the conclusions of both shall be submitted to the council.

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There shall be formed an executive committee of the council, consisting of three heads of divisions of the Department of Astronomical Observations, to be designated by the Superintendent.

The executive committee shall have charge of all editing and printing pertaining to the Department of Astronomical Observations, and in addition shall undertake any other duties which may be assigned to it by the Superintendent or by the council.

The executive committee shall audit the accounts of the observatory arising from the expenditure of appropriations coming under the following subheads: Miscellaneous computations, Department of Astronomical Observations; professional and scientific books; apparatus and instruments and for repairs of same.

The heads of divisions of the Astronomical Department shall submit their monthly reports of progress to the Superintendent, and these shall be laid before the council.

The council shall meet monthly, except in August, and at such other times as the Superintendent may direct.

A clerk shall be detailed to act as Secretary of the council and of the executive committee, who shall keep minutes of each meeting in a book or other proper file.

Should the Superintendent not act on the advice of the council, he shall give his reasons therefor, and they shall be entered upon the minutes.

In approving this order, Secretary Newberry commented as follows:

The astronomical work of the Naval Observatory shall be so planned and executed as best to subserve the following purposes, and no others, to wit:

To furnish to the Nautical Almanac Office, as far as may be possible, such observations and such data as may be needed for carrying out the purpose of the law under which the appropriations for that office are made from year to year, which is as follows:

For . . . preparing for publication the American Ephemeris and Nautical Almanac and improving the tables of the planets, moon, and stars. . . .

The principal work of the observatory shall be in the field of the astronomy of position as distinguished from astrophysical work, and shall be the continued maintenance of observations for absolute positions of the fundamental stars and of stars which are to be made fundamental, and in addition the independent determination by observations of the sun, of the position of the ecliptic, and of the equator among the stars, and of the positions of the stars, moon, and planets with reference to the equator and equinoxes.

Time Service. The Naval Observatory furnishes the accurate time of the United States. One of the earliest activities undertaken

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by the Depot of Charts and Instruments, the predecessor of the Naval Observatory, was the determining of the correct time, by means of astronomical instruments in order to find the errors and rates of the navy chronometers, a service which began about the year 1830 and has continued to the present day. From this simple activity, the astronomic work of the Naval Observatory has expanded so that at present an elaborate system of continuous observations for time, and for the broadcasting of time signals, is maintained.

The standard time of the Naval Observatory is ascertained by means of the stars. Whenever the weather conditions permit, observations are made of the passage over the meridian of the Observatory of so-called clock stars. From the Ephemeris the exact time is known when these stars pass the meridian. To observe and record this passage, a telescope is set permanently in the meridian and is provided with a suitable mechanism for accurately determining when the stars pass the meridian. The times so determined are recorded by means of chronographs. In this way the errors of the standard clocks are constantly ascertained through observations of the stars. Since November, 1922, the observations for time have been made with two instruments, a six-inch transit circle and a Prin three-inch portable transit.

The clock system in use is one of the best that has been devised. There are three Riefler standard sidereal clocks in use, mounted in a vault, secured to solid piers set so far in the earth as to avoid all tremors or vibrations, except earthquakes, and they are run under a constant temperature of 84° F. They are sealed in glass cases in which the air pressure is maintained constant at approximately 650 mm., the pressure being adjusted to make the rate of each clock small.

The time signals are transmitted twice daily, including Sundays and holidays, at noon and at 10 p. m., 75th meridian time, two auxiliary mean time clocks being used for this purpose. Up to 1902, these signals were three minutes and fifteen seconds long, but since that year they have been five minutes in length. Shortly before the time for the signals, these clocks are set correctly by comparison with the standard clocks and at the signal time, the transmission of the signals is made automatically to the electric relays, whence they are transmitted by radio, telegraph, and telephone.

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In 1925 radio time signals were being sent from stations at Arlington, Annapolis, Balboa, Cavite (Philippine Islands), Eureka (California), Great Lakes, Key West, New Orleans, North Head (Washington) Pearl Harbor (Hawaiian Islands), Philadelphia, San Diego, and San Francisco, with stand-by stations at Charleston (South Carolina), New York, and Norfolk. The signals are sent by direct wire from the Naval Observatory at Washington to Arlington and Annapolis. All the others go through certain relays. The service for the Pacific Coast is furnished by the Naval Chronometer and Time Station at Mare Island, California. The signals are also automatically rebroadcast by a number of privately-owned radiophone broadcasting stations. The noon signals are widely distributed by the Western Union and Postal Telegraph companies. The actual lag of the Annapolis and Arlington radio stations is regularly measured at the Naval Observatory, but the difference, or lag, does not generally exceed a tenth of a second. The lags of other stations have been measured from time to time.

The Naval Observatory receives and records foreign time signals, thus furnishing a continuous basis for international time comparison. Time signals from Bordeaux, France, are received regularly. Likewise, the Naval Observatory's time signals are observed in a number of foreign countries for the same purpose, including Canada, England, France, Mexico, South Africa, and when possible, Australia and New Zealand.

The time signals reach the naval and merchant vessels at sea anywhere within a radius of three or four thousand miles of Washington. They give them that exact time without which they cannot safely navigate. In war time it is the only means whereby the location of rendezvous at sea by naval vessels is made possible. Having the exact Washington (or Greenwich) time thus furnished them, navigators by making astronomical observations, are enabled at any time to determine their exact longitude at sea.

Throughout the country the clocks of railroad and navigation companies and other transportation services, and indirectly, all the clocks in private use, are regulated by the Naval Observatory signals. The astronomical work of the leading private observatories, such as those at Harvard and Yale, and the Yerkes Observatory is dependent upon these signals.

The time signals are also utilized in the determining of longitude throughout the world, enabling mariners and surveyors to

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ascertain accurately the positions of islands, coast lines, and points on the mainland. Foreign governments frequently use these time signals because of their known accuracy. They are also used by the Coast and Geodetic Survey for gravity determinations.

Additional time signals are sent out from time to time for special scientific work. During the fiscal year 1925, such special time signals were sent for the use of the Canadian Government and for the United States Coast and Geodetic Survey for longitude determinations in Canada, in the United States, and the Western Aleutian Islands; also for the use of astronomers in Mexico, New Zealand, and Australia. On January 24, 1925, two special signals were sent *via* Arlington and Annapolis at 8.40 a. m. and 9.40 a. m. for the use of persons observing the total eclipse on that day.

A plan is under consideration for determining, by wireless, a longitude net around the world, using the towers at Annapolis, Pearl Harbor, and Bordeaux, and occupying observing stations at San Diego, Shanghai, and Algiers. The purpose of this plan is to obtain fundamental points for the adjustment of charts covering all the earth, and to secure data as to a possible movement of the earth's crust.

The work of testing and rating chronometers and time pieces for the Navy continues to be one of the time-service activities. During the fiscal year 1925, the Naval Observatory received 1908 time pieces, comprising 315 chronometers, eighty-eight torpedo boat watches, 319 patrol boat watches and chronometers, 253 stop and comparing watches, and 933 deck, boat, airplane and wall clocks. Of these time pieces 390 were received new for tests; 1154 old for tests; and 364 old for repairs. During that year the observatory issued for use 123 chronometers, forty-two torpedo boat watches, and 158 patrol boat watches.

Preparation of American Ephemeris and Nautical Almanac. The Naval Observatory, through its Nautical Almanac Office, makes the computations for and prepares for publication each year, the American Ephemeris and Nautical Almanac for the use of astronomers, navigators, surveyors, and others requiring the positions and movements of the heavenly bodies. The Nautical Almanac Office revises the tables which it has made of the sun, moon, and planets, and makes new tables of these objects, as well as catalogues of fundamental stars. In the Ephemeris it predicts about

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two years in advance, the positions of the heavenly bodies, information which is indispensable to seamen for safe navigation, and to astronomers and surveyors for accurate work in their respective fields. This information is also useful in other branches of scientific and industrial work.

In the government service the Ephemeris and the Nautical Almanac are utilized by the Navy Department; by the transport and the engineering services of the War Department, especially in time of war; and by the Coast and Geodetic Survey, the Coast Guard, the Bureau of Lighthouses, the Weather Bureau, and the General Land Office.

The Ephemeris gives complete information of all celestial phenomena for the year; such as eclipses, occultations, the movements of planets, etc., tables for converting time and for finding latitude, and the time of sunrise and sunset and moonrise and moonset. Up to January 1, 1913, the positions of the sun were given in both the Ephemeris and Nautical Almanac once every twenty-four hours, but on account of the increased speed of vessels and the importance of shortening the time of computations, these positions have since been given every two hours for every day of the year. These positions have to be calculated in advance, as they change from day to day and from hour to hour.

In the preparation of the data which go into the American Ephemeris and Nautical Almanac, the Nautical Almanac Office depends to some extent upon the coöperation of the nautical almanac offices of certain foreign countries. This is authorized by an act of August 22, 1912 (37 Stat. L., 328, 342), "with a view to reducing the amount of duplication of work in preparing the different nautical and astronomical almanacs and increasing the total data which may be of use to navigators and astronomers, available for publication in the American Ephemeris and Nautical Almanac." Coöperative arrangements have been entered into with Great Britain, France, Germany, and Spain, with the result that increased information has been made available for navigators and astronomers without additional expense to the coöperating almanac offices.

Most of the foreign almanacs, as well as that of this country, obtain their data pertaining to the sun, planets, and stars from the tables prepared in the American Nautical Almanac Office.

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Astronomical Observations for Position. To insure the requisite accuracy in the determination of time and in the preparation of the data for the Nautical Almanac, continuous and numerous astronomical observations must be made of the sun, moon, planets, and stars, to ascertain their absolute positions. This work of position is the main business of the astronomic branch of the Naval Observatory. The information obtained from these observations and computations is indispensable for the determination of time, longitude, and latitude; for the preparation of the Nautical Almanac; and for other astronomical, navigational, engineering, and scientific work.

Unlike private astronomical observatories, the Naval Observatory concerns itself with the continuous heavy, tedious labor of determining accurate positions of the heavenly bodies and the fundamental astronomical constants. It deals with the work of position or astrometry, as distinguished from astrophysical work carried on in most other observations in the United States. While a certain amount of research work is done at the Naval Observatory, 85 per cent of the observations are for position. Thus, the Naval Observatory fills a place in the field of practical astronomy not occupied by any other organization in the United States.

The work of the Naval Observatory includes continuous observations of the sun, moon, planets, and principal fixed stars; the determination from these observations of the position of the ecliptic and of the equator among the stars; observations of satellites, asteroids and comets; and the determination of fundamental astronomical constants.

A task was recently completed by one astronomer of the observatory staff, consisting of a series of observations extending over a period of about nineteen years, to determine the constants of aberration and nutation, the variation of latitude, the stellar parallax and the proper motion of selected stars. Another series of approximately 50,000 observations of the old standard stars and of additional stars selected to be standard, extending over a period of eight years, was recently completed. A third series of observations, begun in 1913, and including 72,000 observations, will furnish the positions of over 10,000 stars, most of which are needed in connection with an international photographic survey of the heavens.

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Highly accurate continuous observations with the photographic zenith tube are being made for the variation of latitude and for the aberration constant. A correction for latitude variation has to be applied to most of the position observations taken at the Observatory. As this variation cannot be accurately predicted, it is necessary to follow it continuously at or near the place where position observations are taken. The variation of latitude as determined in this way is necessary for the reduction of observations made with the transit circles.

The Observatory makes daily photographs of the sun with a photo-heliograph whenever the weather conditions are favorable. In 1925 such photographs were made on 247 days, and 213 of which sun spots were shown. These photographs are used in a study of the relation between solar conditions and magnetic storms on the earth. It has been observed that when sun spots are large, especially when they approach the center of the sun's disc, electric disturbances affect the working of cables and telegraph lines and at times become so acute as to interrupt communication. As several days elapse before the spots work from the edge to the center of the sun, the greater magnetic disturbances can be anticipated and precautions taken in advance. For this reason, as soon as sun spots are discovered near the limb of the sun, reports of them are made by mail on a regular form to the telegraph and cable companies, and if the spots are large, the fact is telegraphed to them. The data are charted by the telegraph companies together with their own observations of line disturbances, and copies of the charts are forwarded to the Naval Observatory. Notice of these expected disturbances enables the telegraph companies to take precautions against heavy induced currents, thus saving damage and expense due to destruction of their cables. The photographs of the sun spots are also examined with reference to the possible relation between solar disturbances and cable and radio disturbances, by the United States Radio Research Laboratory of the Bureau of Engineering of the Navy Department.

The Observatory has been making observations of total solar eclipses, whenever the money was available, since about 1869. These observations are valuable in checking up the positions of the sun and moon, for studying the solar corona, and for studying the phenomena of electric disturbances. The sun spots, which occur

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in periods of about every eleven years, have quite an effect in creating electrical disturbances on the earth. When an eclipse takes place, the shape of the corona, which is different at different times, is seen to vary with the sun spots cycle, and one can determine more from observing the coronas than one can at any other time between the eclipses.

All these observations, in order to be of value, must be reduced by various complicated calculations to arrive at the final results. This involves a great amount of the most careful mathematical work.

The Naval Observatory renders an important service to the Hydrographic Office by instructing naval officers in field astronomy. When surveying parties make extended surveys of coast lines and soundings, it is necessary for them to locate reference points, both in latitude and longitude, adjacent to those shore lines, from which proper triangulation may be made. When naval officers are detailed for such work on survey vessels, they are first ordered to the Naval Observatory for the purpose of receiving instruction in the method of making time and latitude determinations with the astronomical instruments which they will use in the survey.

These instructions consist in having the naval officer take the unmounted instrument and establish it in the meridian by means of his own observations. When the instrument is so adjusted, the officer is taught how to observe the transit of selected stars from which is derived the error of the time-piece used. This error being known, he can at once find the true local time of his station, and by comparing that with the radio time signal sent out by the clock at the Naval Observatory, he can determine the difference of longitude between the two places. He is also taught how to select stars grouped in pairs, and through observations made of them he can determine the latitude of the instrument with an error that should not exceed twenty-five feet on the earth's surface.

During the fiscal year 1925, the astronomical work performed by the principal instruments comprised the recording of over 11,200 regular observations, determinations of constants, and other standard operations. During that year, 3133 visitors were received at the Naval Observatory and given views of the heavens through the telescopes.

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Navigational Instruments. Among the important functions of the Naval Observatory are the development, testing, supply, upkeep, repair, and inspection of all navigational and surveying instruments for naval vessels, submarines and aircraft, including the rating of chronometers and other time pieces. These were the original functions of the predecessor of the present Naval Observatory. They are correlated with the astronomic work of the Observatory.

The Observatory handles all the business of the Navy Department pertaining to the purchase and supply of navigational and surveying instruments, from a $30,000 gyro-compass in a dreadnaught to a toy balloon for measuring air currents, including among others, chronometers; clocks and watches; sextants, binoculars, telescopes, and stadimeters; barometers; and aviation instruments. The transaction of this business involves much clerical work and storekeeping.

A shop is maintained for the repair of nautical, astronomical and other instruments used at the Observatory, on vessels, and at stations on the Atlantic Coast. Before the establishment of this shop, repairs were made by contract, a practice which was found to be unsatisfactory. The repair shop more quickly responds to the needs of the service, especially where priority is required for urgent jobs, and it does better work at less cost than could be done under the contract system. During the World War this shop was invaluable for these reasons, and also because the skilled workers were able to tell what was needed on contracts for instruments and to advise contractors in their production. During the fiscal year 1925, 4771 instruments were repaired at a total cost of $25,666.85 as follows:

Alidades	5	Mirrors, resilvered	855
Altimeters	607	Peloruses	15
Azimuth circles	49	Plotting boards	25
Barographs	10	Protractors, 3-arm	18
Barometers	24	Psychrometers	7
Binoculars	356	Sextants	245
Chronometers	77	Spyglasses	290
Chrometer boxes	142	Stadimeters	53
Clinometers	28	Telescopes	8
Clocks	643	Thermographs	5
Compasses	303	Theodolites	4
Compasses, aero	327	Transits	12
Dividers	6	Universal drafting machine	60
Magnets	249	Watches	280
Miscellaneous instruments	53	Miscellaneous instruments, aero.	15

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All new and all repaired chronometers for the use of the Navy are thoroughly tested at the Naval Observatory before they are sent out. Among the instruments developed here is the gyroscope compass, which is employed in navigation and in connection with the fire control on which the accuracy of gun and torpedo fire depends.

Whenever naval vessels return from surveying expeditions, their instruments are sent to the Naval Observatory, where they are repaired and tested before the vessels start out again. Also, when a naval vessel goes out of commission, the compass and chronometer records are sent to the Observatory. The commandants of shore stations send monthly reports of compass material which they have in store, to the Observatory.

All correspondence of the Bureau of Aeronautics of the Navy Department relating to the design, procurement, and issue of aeronautic navigational instruments, is handled by the Observatory.

The following statement for the fiscal year 1925, gives an idea of the stock on hand and the number and value of instruments handled by the Naval Observatory:

Value of stock on hand July 1, 1924	$1,984,353.58	
Value of instruments, etc., purchased	46,205.28	
Value of instruments, etc., from stations and ships	213,924.20	
Value of instruments, etc., issued and expended		$193,467.86
Value of stock on hand June 30, 1925		2,051,015.20
		$2,244,483.06

Number of shipments received	1,497
Number of instruments and parts received	40,821
Number of shipments made	1,202
Number of instruments and parts shipped	36,065

It is a policy of the Naval Observatory to encourage suggestions and to develop methods and instruments for navigation, and it sends out to the service for trial such as give promise of usefulness. This policy has produced good results, especially in the matter of instruments for submarines and aircraft use.

Coöperation with Astronomical Organizations. The Naval Observatory has been represented whenever international astronomical conferences were held, and members of the staff have taken

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an active part in such conferences. Several of the astronomers are members of the American Astronomical Society, and some are members of the International Astronomical Union and serve on committees of that organization. The present Director of the Nautical Almanac is Chairman of the Committee on Ephemerides. As many as possible of these members attend the various meetings of the astronomical organizations. In 1925, the Superintendent of the Naval Observatory attended the meeting of the International Astronomical Union at Cambridge, England.

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CHAPTER III

ORGANIZATION

The organization of the Naval Observatory consists of the offices of the Superintendent and Assistant Superintendent, the offices of the Astronomical Council and Executive Committee; the Library; the Administrative Section; the Astronomical Branch, which comprises the Department of Astronomical Observations, with its five divisions, and the Department of Nautical Almanac; and the Nautical Branch, which consists of the Department of Material, with its six divisions.

The personnel consists of ten commissioned naval officers, ranging in rank from captain of the Navy down, detailed for that service by the Secretary of the Navy, including three of the corps of professors of mathematics of the Navy; and eighty-seven civilians, of whom twenty-eight are astronomers of various grades, one is a librarian, eight are clerks, nineteen do nautical instrument repair work, and thirty-one are mechanics, watchmen, laborers, etc. All civilian appointments are made from the eligible lists of the Civil Service Commission.

Offices of the Superintendent and Assistant Superintendent. All the work of the Naval Observatory is under the direction of a Superintendent who is a naval officer required by law to be "not below the rank of captain of the Navy."[1] The Superintendent of the Naval Observatory reports to the Chief of the Bureau of Navigation, who holds the rank of rear admiral. There is an Assistant Superintendent with the rank of captain in the Navy who is also head of the Supply Division.

Astronomical Council. The membership of the Astronomical Council comprises the Superintendent and Assistant Superintendent of the Observatory, the Director of the Nautical Almanac, and the heads of divisions in the Department of Astronomical Ob-

[1] See page 83.

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servations. The Council meets once a month to discuss the progress of the Observatory work, and to advise the Superintendent regarding that work and new work to be undertaken.

Executive Committee. The Executive Committee consists of three members of the Council. This committee has immediate supervision over the computing section, the electrician, and the instrument maker. It also passes upon proposed expenditures up to a certain amount. Larger amounts must be submitted to the Council. It handles such routine matters as are referred to it by the Superintendent, and it audits the accounts of the Library.

Computing Section. In the Computing Section, which is under the direction of the Executive Committee, much of the routine reductions for the various observing divisions of the Observatory are carried on. The Section also looks after the printing and proof reading of the publications of the observing divisions.

The personnel of the Section consists of one associate and three junior astronomers.

Library. The Library of the Naval Observatory is said to be the most complete astronomical library in the world. Most of its accessions are obtained through exchange. The collection consists of professional and scientific works, reference books, and technical periodicals, being especially strong in journals and reports of transactions of scientific societies. On June 30, 1925, it had 32,711 bound volumes and 6287 pamphlets, or a total of 38,998 books. It is in the charge of a Librarian who also has charge of the distribution of the publications of the Naval Observatory.

Administrative Section. The Administrative Section comprises the Office of the Administrative Assistant, and the care and supervision of the buildings and grounds.

Office of the Administrative Assistant. The Administrative Assistant performs the duties that are usually exercised by a Chief Clerk, having charge of the general correspondence and matters pertaining to finance, supplies and the clerical personnel. The Administrative Assistant is the budget officer of the Naval Observatory.

The working force of this office consists of the Administrative Assistant, four clerks, an assistant messenger, a laborer, and a chauffeur, all of whom are civilians.

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Buildings and Grounds. The working force which looks after the buildings and grounds consists of an engineer, four firemen, a foreman and captain of the watch, a carpenter, a painter, a gardener, nine laborers, and seven watchmen.

Astronomical Branch. This organization group consists of the Department of Astronomical Observations and the Department of Nautical Almanac.

Department of Astronomical Observations. The Department of Astronomical Observations comprises five divisions namely, the Division of Equatorials, Division of nine-inch Transit Circle, Division of six-inch Transit Circle, Division of Photographic Zenith Tube and Alt-Azimuth, and the Division of Prime Vertical Transit Instrument.

Division of Equatorials. Observations in the Division of the Equatorials are made with a twenty-six and a twelve-inch equatorial, and photographs are taken with a photographic telescope and a photoheliograph.

The twenty-six inch equatorial is used for the observation of satellites of the planets for improving the positions given in the American Ephemeris, and for determining the masses of the planets for improving the planetary tables. Observations are also made with this instrument of the occultations of stars by the moon for improving the lunar tables; of eclipses of Jupiter's satellites for testing the uniformity of the earth's rotation period; and of asteroids and comets for determination of their orbits.

The twelve-inch equatorial is used for the observation of bright comets and asteroids and of occultations of stars. This instrument is used for showing visitors the heavens, cards of admission being issued to applicants.

The photographic telescope is employed for observations of asteroids in a selected zone for the purpose of keeping track of these objects and to furnish positions for improved orbits. It is equipped with an electric driving clock.

The photo-heliograph is used for making daily photographs of the sun, near noon, for recording the sun spots. These photographs are used to study the relation of sun spots to magnetic phenomena, electric storms, and auroras, including disturbances affecting telegraph and cable lines. The Division coöperates

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with the Western Union Telegraph Company and the Bureau of Engineering of the Navy Department in these studies.

The personnel of this Division consists of a Professor of Mathematics, with the rank of commander, and two associate astronomers.

Division of Nine-Inch Transit Circle. The Nine-Inch Transit Circle Division is engaged in observations of the intermediary and standard stars for position, by which reference stars to be used in photographic plates are to be determined. These observations were begun August 1, 1913, and have been continued, together with observations of the sun, moon, planets, and day clock stars, for the improvement of positions. A total of 72,000 observations have been made since the beginning. These observations were suggested by the scheme of the Permanent International Committee on the Photographic Chart of the Heavens.

The personnel of this Division consists of one astronomer, two associate astronomers, and one assistant astronomer.

Division of Six-Inch Transit Circle. The work of the Division of Six-Inch Transit Circle consists in the determination by observation of the positions of the sun, moon, planets, and fundamental stars, and the determination of time for the use of the time service. A Prin transit is also used for the latter purpose. This Division also has charge of the standard clocks and the clock vault.

One astronomer, one associate astronomer, and one assistant astronomer perform the work of this Division.

Division of Photographic Zenith Tube and Alt-Azimuth. In the Division of Photographic Zenith Tube and Alt-Azimuth, observations are made with the photographic zenith tube of stars very near the zenith for determining the variation of latitude and the constant of aberration of light. The determination of the variation of latitude by this instrument is used in the reduction of observations made with the transit circles. The Division also makes alt-azimuth observations of standard stars for the improvement of their declinations. Recently these alt-azimuth observations have been omitted on account of the accumulation of reduction work in the Observatory.

The personnel of this Division consists of a Professor of Mathematics with the rank of captain, and a junior astronomer.

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Division of the Prime Vertical Transit Instrument. In this Division observations of transits over the prime vertical are made and reduced for the purpose of securing modern positions in declination of a list of zenith stars, and of determining their proper motion. A series of observations, practically all made by one man with this instrument and extending over nineteen years, was completed a few years ago and the results are now in print.

The work of this Division is performed by one astronomer.

Department of Nautical Almanac. The Department of Nautical Almanac has charge of the preparation for publication of the annual volumes of the American Ephemeris and Nautical Almanac and of the American Nautical Almanac. It is also charged with the duty of improving the tables of the planets, moon, and stars, to be used in preparing for publication the annual volumes of the office. These volumes predict the position of heavenly bodies, and are issued about two years in advance of the year to which they relate.

The astronomical and mathematical work on which this Department is engaged at the present time includes the determination of new orbits of the satellites of Saturn and of the satellite of Neptune, and researches for improving the positions of fundamental stars. A new star catalogue, entitled "Positions and Proper Motions of 1504 Standard Stars," was recently completed in this Department.

The Department of Nautical Almanac is under the supervision and direction of a Professor of Mathematics with the rank of captain. The office force consists of sixteen astronomers of various grades, of whom five devote only a small portion of their time to this Department. This Department has no subdivisions.

Nautical Branch. While the Nautical Branch is coördinate with the Astronomical Branch, it is made up of a single department.

Department of Material. The Department of Material comprises six divisions, namely, the Magnetic Compass, Gyro-compass, Air Navigation and Aerological Instruments, Nautical Instruments and Time Service, Supply, and Inspection divisions. It is under the direction of a naval officer with the rank of captain, who is also

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Assistant Superintendent of the Observatory, and supply officer. Each division is under the direction of a naval officer.

Magnetic Compass Division. The routine duties of the Magnetic Compass Division consist of: Compass tests and inspections of compass parts, such as needles, jewels, pivots, and cards, and of magnet correctors; scrutinizing and filing compass reports from ships; scrutinizing requisitions and surveys from ships for action pertaining to compass outfits; scrutinizing numerous reports regarding maneuvering and navigational features of ships; consulting with representatives of the Bureau of Construction and Repair of the Navy Department in regard to designs of new ships; and conducting a compass school for giving instruction to officers.

The work of this Division is carried on by one naval officer.

Gyro-Compass Division. The functions of the Gyro-Compass Division, which was created a few years ago, are similar to those of the Magnetic Compass Division. It has charge of the design and procurement of gyro-compasses and their installation on vessels of the Navy; it issues to vessels having gyro-compasses, equipment report forms and record books, and receives from them reports and records concerning the performance of these instruments, their defects or other pertinent matters which may lead to improvement in the operation or design of these compasses. In the early days of gyro development it practically supported that development.

The personnel of this Division consists of two naval officers.

Air Navigation and Aerological Instrument Division. The Air Navigation and Aerological Instrument Division has charge of the handling, inspection, development, etc., of all aircraft compasses and instruments for aerial navigation, ground instruments used in connection with air navigation and the aerological instruments at naval air stations and on board aircraft carriers and aero tenders. It handles the correspondence of the Bureau of Navigation in regard to the design, procurement, and issue of aeronautical, navigational, and aerological instruments.

This Division is in charge of a naval officer who is also chief of the Magnetic Compass Division. He has an assistant with the rank of chief gunner.

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Division of Nautical Instruments and the Time Service. The Division of Nautical Instruments and Time Service tests the nautical instruments and navigation equipment, including chronometers and watches, and directs the supply of the same to newly-commissioned vessels, to regular vessel in commission, to vessels in use for training naval reservists, to vessels of the Bureau of Fisheries, to state school ships, and to the Aircraft Service, including air stations and bases. It supervises the character and quantity of the navigation stock kept at the various naval supply stores and bases for issue and replacement; makes recommendations for the disposal by sale of obsolete and nonstandard material; and supervises repairs to navigational instruments and equipment for the naval service, including the navy yards, naval stations, naval bases, and repair ships. It conducts a nautical instrument repair shop at the Observatory for the repair of instruments of vessels and stations on the Atlantic Coast. It gives consideration to and tests new instruments and devices for use in navigation and in maneuvering vessels.

The Division also has charge of the sending out of the daily time signals at noon and at 10 p. m., 75th meridian time and of the special time signals required at times for geodetic, astronomic, and other scientific work.

The work of this Division is carried on by a naval officer, in charge, and one associate and one junior astronomer, fifteen instrument makers and a janitor.

Supply Division. The Supply Division has charge of the receipt, packing, shipment, and custody of the instruments and instrument parts handled by the Naval Observatory, and keeps a record of the same. It is under the direct supervision of the supply officer, a captain, who is in charge of the Department of Material and is Assistant Superintendent of the Naval Observatory. The civilian force consists of two clerks, one store laborer, and three packers.

Inspection Division. The Inspection Division has charge of the inspection and repair of instruments handled by the Observatory. It surveys all returned instruments and material received from ships and supply offices.

The personnel of this Division consists of one naval officer, assisted by personnel from other divisions as required.

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APPENDIX I

OUTLINE OF ORGANIZATION

Explanatory Note

The Outlines of Organization in this series of monographs have for their purpose to make known in detail the organization and personnel possessed by the several services of the national government to which they relate. They have been prepared in accordance with the plan followed by the President's Commission on Economy and Efficiency in the preparation of its outlines of the organization of the United States government.[1] They differ from those outlines, however, in that whereas the Commission's report showed only organization units, the presentation herein has been carried far enough to show the personnel embraced in each organization unit.

These outlines are of value not merely as an effective means of making known the organization of the several services. If kept revised to date by the services, they constitute exceedingly important tools of administration. They permit the directing personnel to see at a glance the organization and personnel at their disposition. They establish definitely the line of administrative authority and enable each employee to know his place in the system. They furnish the essential basis for making plans for determining costs by organization division and subdivision. They afford the data for a consideration of the problem of classifying and standardizing personnel and compensation. Collectively, they make it possible to determine the number and location of organization divisions of any particular kind as, for example, laboratories, libraries blueprint rooms, or any other kind of plant possessed by the national government, to what services they are attached and where they are located, or to determine what services are maintaining stations at any city or point in the United States. The Institute

[1] House Doc. 458, 62d Congress, 2d Session, 1912—2 vols.

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hopes that upon the completion of the present series, it will be able to prepare a complete classified statement of the technical and other facilities at the disposal of the government. The present monographs will then furnish the details regarding the organization, equipment, and work of the institutions so listed and classified.

OUTLINE OF ORGANIZATION

NAVAL OBSERVATORY

DEPARTMENT OF THE NAVY

MARCH 15, 1926

Unit of Organization; Class of Employee	*Number*	*Annual Salary Rate*
1. Office of the Superintendent		
Superintendent (Captain)	1	[a]
2. Office of the Assistant Superintendent		
Assistant Superintendent (Captain) [b]	1	[a]
3. Office of the Astronomical Council [c]		
1. Executive Committee [c]		
1. Office of the Executive Committee		
Instrument Maker	1	1,860
Electrician	1	1,740
Mechanic	1	1,320
2. Computing Section		
Astronomer (Associate Scientist)	1	$3,000
Astronomer (Junior Scientist)	3	1,860
4. Library		
Librarian	1	2,400
Laborer	1	1,020
5. Administrative Section		
1. Office of the Administrative Assistant		
Administrative Assistant	1	3,000
Clerk	2	1,680
	2	1,500
Assistant Messenger	1	1,020
Laborer	1	1,020
Chauffeur	1 (per diem)	6.50

[a] Pay and allowances of naval rank.
[b] Also supply officer in charge of Supply Division.
[c] For membership of Astronomical Council and Executive Committee, see page 59.

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2. Building and Grounds		
Foreman and Captain of the Watch	1	1,500
Engineer	1	1,740
Fireman	4	1,080
Carpenter	1	1,500
Painter	1	1,860
Gardener	1	1,440
Watchman	7	1,020
Laborer	1	1,260
	1	1,200
	1	1,140
	6	900
6. Astronomical Branch		
1. Department of Astronomical Observations		
1. Equatorial Division		
Astronomer (Commander, ret.) In Charge	1	[a]
Astronomer (Associate Scientist)	2	3,000
2. Nine-Inch Transit Circle Division		
Astronomer (Scientist) In Charge	1	3,800
Astronomer (Associate Scientist)	2	3,000
Astronomer (Assistant Scientist)	1	2,400
3. Six-Inch Transit Circle Division		
Astronomer (Scientist) In Charge	1	3,800
Astronomer (Associate Scientist)	1	3,000
Astronomer (Assistant Scientist)	1	2,400
4. Photographic Zenith Tube and Alt-Azimuth Division		
Astronomer (Captain) In Charge	1	[a]
Astronomer (Junior Scientist)	1	1,860
5. Prime Vertical Transit Instrument Division		
Astronomer (Scientist) In Charge	1	3,800
2. Department of Nautical Almanac		
1. Nautical Almanac Office		
Astronomer (Captain) Director	1	[a]
Astronomer (Scientist)	1	3,800
Astronomer (Associate Scientist)	3	3,000
Astronomer (Assistant Scientist)	8[b]	2,400
Astronomer (Junior Scientist)	4	1,860

[a] Pay and allowances of naval rank.

[b] Two of these devote only a portion of their time to the Nautical Almanac Office work and receive an average of about $500 per annum for their services.

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7. Nautical Branch: Department of Material

1. Magnetic Compass Division		
Commander in Charge	1	[a]
2. Gyro-Compass Division		
Chief of Division (Lieutenant Commander)	1	[a]
Lieutenant	1	[a]
3. Air Navigation and Aerological Instrument Division		
Chief of Division (Commander)	[b] 1	[a]
Gunner	1	[a]
4. Nautical Instrument Division and Time Service		
Chief of Division (Commander)	1	[a]
Astronomer (Associate Scientist)	1	3,000
Astronomer (Junior Scientist)	1	1,860
Foreman Instrument Maker	1 (per hour)	1.02
Instrument Maker	14 " "	.87
Janitor	1 " "	.52
5. Supply Division		
Supply Officer (Captain) [c]	1	[a]
Clerk in Charge	1	2,400
Clerk	1	1,860
Store Laborer	1	1,320
Packer	3 (per hour)	.63
6. Inspection Division		
Commander, Retired, in Charge	1	[a]

[a] Pay and allowances of naval rank.
[b] The same officer is in charge of the Magnetic Compass Division.
[c] This officer is also the Assistant Superintendent of the Naval Observatory.

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APPENDIX 2

CLASSIFICATION OF ACTIVITIES

Explanatory Note

The Classification of Activities have for their purpose to list and classify in all practicable detail the specific activities engaged in by the several services of the national government. Such statements are of value from a number of standpoints. They furnish, in the first place, the most effective showing that can be made in brief compass of the character of the work performed by the service to which they relate. Secondly, they lay the basis for system of accounting and reporting that will permit the showing of total expenditures classified according to activities. Finally, taken collectively, they make possible the preparation of a general or consolidated statement of the activities of the government as a whole. Such a statement will reveal in detail, not only what the government is doing, but the services in which the work is being performed. For example, one class of activities that would probably appear in such a classification is that of "scientific research." A subhead under this class would be "chemical research." Under this head would appear the specific lines of investigation under way and the services in which they were being prosecuted. It is hardly necessary to point out the value of such information in planning for future work and in considering the problem of the better distribution and coördination of the work of the government. The Institute contemplates attempting such a general listing and classification of the activities of the government upon the completion of the present series.

Classification of Activities

1. Furnishing correct daily time.
2. Computing and preparing for the publication, American Ephemeris and Nautical Almanac.

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3. Maintaining continuous observations of the heavenly bodies for position and time.
4. Developing, supplying, keeping up, repairing, and inspecting navigational, aeronautical, and aerological instruments for naval vessels and aircraft and instructing persons engaged in hydrographic surveys.

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APPENDIX 3

PUBLICATIONS[1]

The present publications of the Naval Observatory consist of the Annual Report of the Superintendent; the annual American Ephemeris and Nautical Almanac, and the smaller edition, the American Nautical Almanac; and two series of publications entitled "Astronomical Papers of the American Ephemeris" and "Publications of the U. S. Naval Observatory, Second Series" (formerly issued as "Washington Observations") the volumes of which appear at irregular intervals.

Annual Report. Annual Reports of the Superintendent of the Naval Observatory have been issued with a few exceptions since 1847, and what might be called the annual report for 1846, appears in the appendix to the Washington Observations for 1845. The exceptions are the fiscal years 1848 to 1850, 1854, 1862, and 1921, when no annual reports were issued, but a synopsis of the report for 1921 was printed as a part of the report for 1922. These printed reports of the Superintendent appeared in the annual reports of the Navy Department, except that the report for 1902 appeared as part of the report of the Equipment Bureau. The annual reports for 1846 and for 1862 to 1892 appeared also in the Washington Observations. These Annual Reports have also been issued separately for the fiscal years 1878, 1884 to 1894, and from 1897 to the present time. From 1906 to 1911 they were entitled "Synopsis of Report of Superintendent," and extracts from these synopses were included in the annual reports of the Navy Department.

American Ephemeris and Nautical Almanac. The annual publication of the American Ephemeris and Nautical Almanac was

[1] The publications of the Naval Observatory are for sale by the Superintendent of Documents, Government Printing Office, Washington, D. C. Those on sale are listed in "Price list 48, weather, astronomy and meteorology," which list is supplied free, on application to the Superintendent of Documents.

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provided for in the act of March 3, 1849 (9 Stat. L., 375). The first issue appeared in 1852, containing data for 1855. Until 1858 it was published by a separate office directly under the Secretary of the Navy, and from 1859 to 1894, under the same bureaus as the Naval Observatory. Since 1894 the Nautical Almanac Office has been a part of the Naval Observatory.

This publication predicts the positions of the heavenly bodies two years in advance. It consists of three parts: Part 1, Ephemeris for the meridian of Greenwich; Part 2, Ephemeris for the meridian of Washington; and Part 3, predictions of principal astronomical phenomena of the year to be observed, with data for their computation. Sometimes more than one edition is issued. Beginning with the volume for 1925, the mean solar time used in this publication, is for the civil day which begins at midnight, twelve hours earler than the day of corresponding date in previous volumes. The American Nautical Almanac contains only such positions of the Ephemeris for the meridian of Greenwich and astronomical tables as are needed in navigation. It is about one-fifth the size of the larger volume.

From time to time supplements to the American Ephemeris have been issued dealing with various astronomical subjects.

Other Almanacs. While the above are the only almanacs now published by the Naval Observatory, there were issued annually from 1884 to 1892 an "Atlantic Coaster's Nautical Almanac," and from 1855 to 1906 a "Pacific Coaster's Nautical Almanac."

Astronomical Papers. The astronomical papers, which have been published since 1882, are prepared for the use of the American Ephemeris and Nautical Almanac, and appear at irregular intervals. The objects of this series of publications, as explained in the first volume, "are a systematic determination of the constants of astronomy from the best existing data, a reinvestigation of the theories of the celestial motions, and the preparation of tables, formulae, and precepts for the construction of ephemerides, and for other applications of the results. The adopted policy . . . contemplates the subdivision of the work and the publication of each part as soon as completed in such a way as to render easy the subsequent combination of the whole." They are voluminous documents, containing tables of motions of the planets, fundamental star catalogs, astronomical formulae, and other data of a

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highly technical character. They usually appear in four, five, and six parts, each part being devoted to a particular subject. Eight volumes complete, and parts of Volumes IX and X have been issued, the last in 1925. These papers are used quite generally in the preparation of the national ephemerides of foreign countries.

Publications of the U. S. Naval Observatory, Second Series. The first series of publications of the U. S. Naval Observatory was known by the general term "Washington Observations." The earliest publication of observations of the Naval Observatory was a report on "Magnetic and Meteorological Observations" by Lieutenant J. M. Gilliss, U. S. N., dated August 13, 1838, and published in 1845. A report on astronomical observations made during the years 1838 to 1842 was issued in 1846. This was followed by the series, Washington Observations, which were issued for individual years from 1846 until 1892, except that in several instances the observations for two years, and in one case, the observations for eight years, were published in one volume. The Washington Observations were variously designated as astronomical observations for the years 1845 to 1852 inclusive; results of observations made, etc., for the years 1853 to 1860; astronomical and meteorological observations, for the years 1861 to 1882; observations, for the years 1883 to 1889; and astronomical, magnetic, and meteorological observations made during 1890 to 1892.

The second series of these publications designated as the Publications of the U. S. Naval Observatory, was begun in 1900, and the issues have been continued at irregular intervals, Volume X having appeared in 1926.

Appendices to, and other extracts from both of these two series of publications, have at times been published as separates.

The publications of these two series contain the results of astronomical observations and computations, and of meteorological, magnetic, and other scientific studies which have occupied the attention of the Naval Observatory.

Other Publications. In addition to the serial publications, the Naval Observatory has issued either directly or through the Nautical Almanac Office, annual reports of Board of Visitors, two reports made in 1899 and 1901; catalogs of the library of the Naval Observatory, issued in 1868 and 1879; and individual

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publications on a large variety of subjects pertaining to the work of the Naval Observatory and the Nautical Almanac Office.

Individual Contributions to Current Scientific Literature. The Superintendent sends from time to time scientific articles, prepared by members of the staff, to astronomical journals; papers are read by them before scientific societies; and many articles are prepared by staff members for publication in other periodicals. An idea of the extent to which the personnel of the Naval Observatory contributes in this way to current scientific literature may be obtained from the following list of such contributions during the fiscal year 1925:

Astronomical Journal—

1. Elements and Ephemeris of 1923 W 21, by Ernest Clare Bower and John Edwin Willis. (No. 839.)
2. Orbit of the Fifth Satellite of Jupiter, by James Robertson. (No. 840.)
3. Observations of (433) Eros, by Asaph Hall and Ernest Clare Bower. (No. 840.)
4. Report on Observations of Transit of Mercury, May 7, 1924, by F. B. Littell. (No. 844–845.)
5. Observations of 1923PE, by Ernest Clare Bower. (No. 844-845.)
6. Variation of Latitude at the U. S. Naval Observatory, by F. B. Littell. (No. 844–845.)
7. Occultations by the Moon, 1924-25, by Asaph Hall, Ernest Clare Bower, and John Edwin Willis. (No. 849.)
8. Observations of 1924c (Finsler), by Ernest Clare Bower. (No. 849.)
9. Eclipse of Sun, January 24, 1925, by Capt. E. T. Pollock, U. S. N. (No. 849.)
10. Observations of the Moon, by H. R. Morgan. (No. 850.)

Other Contributions—

Studying the Eclipse from the *Los Angeles,* by Capt. Edwin T. Pollock, U. S. N., in McClure's Magazine, June, 1925.

The New System of Fundamental Star Places of the American Nautical Almanac Office, by W. S. Eichelberger, in the Astronomische Nachrichten, March 7, 1925.

On Provisional Designations of Asteroids, by Ernest Clare Bower, in the Astronomische Nachrichten, Bd. 223, p. 150.

Shadow Pictures of Waves in the Atmosphere, by John E. Willis, in Popular Astronomy, June-July, 1925.

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APPENDIX 4

PLANT AND EQUIPMENT

Buildings and Grounds. The Naval Observatory must necessarily be located where its delicate instruments are undisturbed, and where the atmosphere is free from the smoke and heat radiation arising from surrounding buildings. It is therefore situated in one of the highest positions of Washington in the midst of an eighty-one-acre plot of ground. Of these eighty-one acres, sixty-two consist of building sites, lawn, flower beds, and parking, and the rest, of woods.

There are fifty-four buildings altogether, ranging from a small shelter to a large office building, and comprising instrument houses, stock-rooms for navigational instruments, a repair shop, etc. Of the fifty-four buildings, eighteen are heated by a large steam plant of two boilers.

As heavy traffic near the instruments would cause vibrations that would interfere with observations, an act was approved August 1, 1894 (28 Stat. L., 588), prohibiting the construction of any highways within the area of a circle described with a radius of one thousand feet from the center of the clock room of the Observatory. The circle thus described is to be a part of the acreage property belonging to the Naval Observatory, but about seven acres yet remain to be acquired.

Major Equipment. The equipment of the Naval Observatory includes the following instruments:

A six-inch meridian circle, with horizontal and vertical collimators, and north and south meridian marks, and a personal equation apparatus mounted in connection with one of the marks. The instrument can be easily reversed and the object glass and eye-end can be interchanged. Both circles are accurately divided. The instrument is provided with a hand driven impersonal micrometer. This meridian circle was specially designed for making fundamental observations.

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Two three-inch portable transits, each provided with a motor-driven impersonal micrometer.

Four Riefler clocks, in glass bell jars. Three of these clocks are mounted in a vault and are run under constant temperature and pressure and are used as the standard clocks of the Naval Observatory.

A special type of thermograph. This was designed and constructed at the Naval Observatory. It is placed in one of the rooms of the main building and gives a continuous record of the temperature of the clock vault.

A nine-inch meridian circle, with horizontal and vertical collimators and north and south meridian marks, and a personal equation apparatus mounted in connection with one of the marks. In connection with this instrument a printing chronograph is employed.

A twenty-six-inch equatorial with micrometers, including a large filar micrometer of the best type, provided with a printing arrangement to record pointings of the micrometer screw.

A photographic equatorial carrying two ten-inch triple photographic lenses of 113 inches focal length, each giving a field on the 8″ x 10″ photographic plates of 4° x 5°. The guiding telescope has an aperature of 9.6 inches. The curves for the ten-inch lenses were computed and the lenses were figured at the Observatory.

A photo-heliograph of five inches aperture and forty feet focal length, with which daily photographs of the sun are taken.

A twelve-inch equatorial with micrometer.

A five-inch alt-azimuth. This instrument is mounted in a building especially constructed to take on quickly the outside temperature, and avoid room refraction.

An eight-inch photographic zenith tube, in a specially constructed building, for the determination of the variation of latitude.

A five-inch prime vertical transit with east azimuth mark.

A special objective of sixty-five feet focal length for eclipse work.

Six five-inch portable equatorials.

Four combined transit and zenith telescopes.

An automatic radio recording apparatus, consisting of a standard tuner with a radio and audio amplifier and a recording unit operating a special relay. Excepting the tuner, this equipment

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was designed and constructed at the Observatory. By its use it is possible to record graphically on an ordinary chronograph sheet, radio signals from all stations within the range of the receiver. Whenever a signal is sent out there is recorded the time that the signal ticks occur at the Observatory, and on the same sheet the time that they are received back by radio, thus permitting accurate measurement of the operating time or lags of the transmitting stations. Automatic records are also regularly made of time signals received from Bordeaux, France, and from time to time records have been made of time signals sent from Lyons, France; Nauen, Germany; Balboa, Canal Zone; San Diego, California, and other points.

An automatic electrical temperature control apparatus in the temperature room used for testing chronometers. This apparatus was designed and installed by the time service. An ordinary large relay is used which has been altered so as to permit it to control heavy currents.

A watch winding machine designed and made at the Naval Observatory.

A special "chronogram reader" for rapid reading of chronometer comparisons, designed and made at the Naval Observatory.

Apparatus for testing sextants and sextant mirrors in the Department of Material.

A library which is especially rich in astronomical and mathematical journals and in the publications of the academies of science.

A shop for the repair of navigational instruments for the fleet. These instruments include sextants, theodolites, ships' telescopes, binoculars of all kinds, azimuth circles, mercurial and aneroid barometers, and magnetic compasses. The shop possesses a high grade graduating engine, for graduating circles up to one metre in diameter, and has a lineal graduating engine. The shop is also equipped for repairing and compensating chronometers, high grade watches and clocks. A small shop is equipped for special work on the astronomical instruments.

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APPENDIX 5

LAWS

A. Index to Laws

Appropriations for the fiscal year, 1926.....43 Stat. L., 861, 868
Duties and powers of
  Nautical Almanac Office
    Employees, use of, for other work.....37 Stat. L., 328, 342
    Exchange of data with foreign offices.....37 Stat. L., 328, 342
    Supervision of .....11 Stat. L., 243, 246
  Naval Observatory:
    Board of visitors; duties of.....31 Stat. L., 1107, 1122
    Facilities allowed scientific investigators and students...27 Stat. L., 395
                31 Stat. L., 1010, 1039
    Regulations, concerning duties.....31 Stat. L., 1107, 1122
Observatory circle .....28 Stat. L., 588
Personnel
  Nautical Almanac Office
    Director, acting .....37 Stat. L., 360, 393
    Director, detail and pay of.....31 Stat. L., 1107, 1122
          qualifications of .....9 Stat. L., 373, 375
  Naval Observatory
    Astronomical director and astronomers, appointment or
      detail of .....31 Stat. L., 1107, 1122
    Board of visitors, appointment of.....31 Stat. L., 1107, 1122
    Professors of mathematics, appointment of.....9 Stat. L., 266, 272
                39 Stat. L., 556, 577
    Superintendent, qualifications of .....31 Stat. L., 1107, 1122
              pay of .....13 Stat. L., 533
Publications
  American Ephemeris and Nautical Almanac, and observa-
      tions: printing, distribution and sale of extra copies of
                28 Stat. L., 601, 613
                32 Stat. L., 662, 678
                32 Stat. L., 740

B. Compilation of Laws

1848—Act of August 3, 1848 (9 Stat. L., 266, 272)—An Act making appropriations for the naval service for the year ending the thirtieth of June, one thousand eight hundred and forty-nine.

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. . . The . . . professors of mathematics in the navy . . . shall be appointed and commissioned by the President of the United States, by and with the advice and consent of the Senate, and shall perform such duties as may be assigned them by order of the Secretary of the Navy at . . . the Observatory.

1849—Act of March 3, 1849 (9 Stat. L., 373, 375)—An Act making appropriations for the Naval Service for the year ending the thirtieth of June, one thousand eight hundred and fifty.

. . . That a competent officer of the navy, not below the grade of lieutenant, be charged with the duty of preparing the Nautical Almanac for publication.

1857—Act of March 3, 1857 (11 Stat. L., 243, 246)—An Act making appropriations for the Naval Service for the year ending the thirtieth of June, eighteen hundred and fifty-eight.

. . . Hereafter it shall be lawful for the Secretary of the Navy to place the supervision of the compilation and publication of the Nautical Almanac in charge of any officer or professor of mathematics of the Navy of competent qualifications: *Provided,* That such officer or professor when so employed shall receive no higher pay than the duty pay to which his grade shall entitle him.

1865—Act of March 3, 1865 (13 Stat. L., 533)—An Act in relation to the Naval Observatory.

[Section 1]. . . . No officer of the Navy employed as superintendent [of the Naval Observatory] shall receive other than the shore-duty pay of his grade.

1892—Joint Resolution of April 12, 1892 (27 Stat. L., 395) [1]—Joint resolution to encourage the establishment and endowment of institutions of learning at the national capital by defining the policy of the Government with reference to the use of its literary and scientific collections by students.

. . . The facilities for research and illustration in the following Government collections . . . now existing or hereafter to be established in the City of Washington for the promotion of knowledge shall be accessible under such rules and restrictions as the officers in charge of each collection may prescribe, subject to such authority as is now or may hereafter be

[1] An Act of March 3, 1901 (31 Stat. L., 1039), makes similar provision without specifically mentioning the Naval Observatory, but including it in general terms.

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permitted by law, to the scientific investigators and to students of any institution of higher education now incorporated or hereafter to be incorporated under the laws of Congress or of the District of Columbia, to wit:
* * * *

Twelve. Of the Naval Observatory.

1894—Joint Resolution of August 1, 1894 (28 Stat. L., 588)—Joint Resolution To establish an observatory circle as a provision for guarding the delicate astronomical instruments at the United States Naval Observatory against smoke or currents of heated air in their neighborhood and undue vibrations from traffic upon the extension of public thoroughfares in the vicinity, and for other purposes.

WHEREAS, IN order to insure within practicable limits the success of astronomical observations, it is of the highest importance that the delicate instruments employed in that work be guarded against smoke or currents of heated air in their neighborhood, and also against undue vibrations from traffic upon public thoroughfares, all of which can only be attained by controlling a reasonable area of ground in the immediate vicinity of the buildings wherein the said instruments are mounted; and

WHEREAS, FROM experiments it has been ascertained that a circle described with a radius of one thousand feet from a central point of the said buildings is the least inclosure that will accomplish such desired protection:

Therefore,

Resolved by the Senate and House of Representatives of the United States of America in Congress assembled, That no street, avenue, or public thoroughfare in the neighborhood of the buildings erected upon the United States Naval Observatory grounds, Georgetown Heights, District of Columbia, shall extend within the area of a circle described with a radius of one thousand feet from the center of the building known as the clock room of the said Observatory.

SEC. 2. That the Secretary of the Navy be, and is hereby, authorized to grant the right of way for the extension of Massachusetts avenue through the limits of the said Observatory grounds exterior to said circle in accordance with the foregoing proviso, and that Massachusetts avenue, as laid down in conformity with that proviso upon the maps of the engineer department of the District of Columbia, through the grounds of the United States Naval Observatory be, and the same hereby is, declared to be a public street in all respects as the other public streets of the District of Columbia.
* * * *

SEC. 5. That the Secretary of the Navy be, and hereby is, authorized to acquire, by purchase, legal title to the several plats of ground, not now belonging to the United States, that are situated within the hereinbefore described circle, amounting to nineteen and twenty-seven one-hundredths acres, more or less, being parts of lands adjoining the present said Observatory site, and comprised in the following portions of land as generally known, namely: Plat east, Normanstone, one and seventy-eight one-hundredths acres, more or less; plat west, Robert Weaver, eight and twenty-

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five one-hundredths acres, more or less; plat west, Barnes, thirty-eight one-hundredths acre, more or less; plat west, Young, sixty-seven one-hundredths acre, more or less; plat west, Barbour, thirty-two one-hundredths acre, more or less; plats north and west, Dunbarton, seven and eighty-seven hundredths acres, more or less.

SEC. 6. That said plats of land, when acquired by purchase, hereinbefore described, shall form a part of the said Naval Observatory grounds.[2]

1895—Act of January 12, 1895 (28 Stat. L., 601, 613)—An Act Providing for the public printing and binding and the distribution of public documents.

* * * *

SEC. 73. Extra copies of documents and reports shall be printed promptly when the same shall be ready for publication, . . . and shall be of the number following in addition to the usual number:

* * * *

Of the Ephemeris and Nautical Almanac and of the papers supplementary thereto, one thousand five hundred copies; one hundred copies for the Senate, four hundred for the House, and one thousand for distribution or sale by the Navy Department. The five hundred copies printed for Congress and the usual number shall be for the calendar year next following, and those for the Navy Department for the third year following. The Secretary of the Navy is also authorized to cause additional copies of the Ephemeris, and of the Nautical Almanacs extracted therefrom to be printed for the public service and for sale to navigators and others: *Provided,* That all moneys received from sales of the Ephemeris and of the Nautical Almanacs shall be deposited in the Treasury and placed to the credit of the general fund for public printing.

Of the Observations of the Naval Observatory, one thousand eight hundred copies; three hundred for the Senate, seven hundred for the House, and eight hundred for distribution by the Naval Observatory, and of the astronomical appendices to the above observations, one thousand two hundred separate copies, and of the meteorological and magnetic observations one thousand separate copies for distribution by the Naval Observatory.

1901—Act of March 3, 1901 (31 Stat. L., 1107, 1122)—An Act Making appropriations for the naval service for the fiscal year ending June thirtieth, nineteen hundred and two, and for other purposes.

* * * *

. . . That there shall be appointed by the President, by and with the advice and consent of the Senate, from persons not officers of the United States a board of six visitors to the Naval Observatory, four to be astronomers of high professional standing and two to be eminent citizens of the

[2] An appropriation of $4,041 was made in the act of December 5, 1924 "to complete the purchase of land lying within the Observatory Circle" as established by this resolution.

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United States. Appointments to this board shall be made for periods of three years, but provision shall be made by initial appointments for shorter terms so that two members shall retire in each year. Members of this board shall serve without compensation, but the Secretary of the Navy shall pay the actual expenses necessarily incurred by members of the board in the discharge of such duties as are assigned to them by the Secretary of the Navy or are otherwise imposed upon them. The board of visitors shall make an annual visitation to the Observatory at a date to be determined by the Secretary of the Navy, and may make such other visitations not exceeding two in number annually by the full board or by a duly appointed committee as may be deemed needful or expedient by a majority of the board. The board of visitors shall report to the Secretary of the Navy at least once in each year the result of its examinations of the Naval Observatory as respects the condition of buildings, instruments, and apparatus, and the efficiency with which its scientific work is prosecuted, and shall also report as respects the expenditures in the administration of the Observatory. The board of visitors shall prepare and submit to the Secretary of the Navy regulations prescribing the scope of the astronomical and other researches of the Observatory and the duties of its staff with reference thereto. When an appointment or detail is to be made to the office of astronomical director, director of the Nautical Almanac, astronomer, or assistant astronomer, the board of visitors may recommend to the Secretary of the Navy a suitable person to fill such office, but such recommendation shall be determined only by a majority vote of the members present at a regularly called meeting of the board held in the city of Washington. The Superintendent of the Naval Observatory shall be, until further legislation by Congress, a line officer of the Navy of a rank not below that of captain.

1902—Joint Resolution of May 13, 1902 (32 Stat. L., 740)—Joint Resolution providing for the printing of the American Ephemeris and Nautical Almanac.

That hereafter the "usual number" of copies of the American Ephemeris and Nautical Almanac shall not be printed. In lieu thereof there shall be printed and bound one thousand one hundred copies of the same, uniform with the editions printed for the Navy Department, as provided in section seventy-three, paragraph five, of an Act approved January twelfth, eighteen hundred and ninety-five, providing for the public printing, binding, and distribution of public documents; one hundred copies for the Senate, four hundred for the House, and six hundred for the Superintendent of Documents for distribution to State and Territorial libraries and designated depositories.

1902—Act of July 1, 1902 (32 Stat. L., 662, 678)—An Act Making appropriations for the naval service for the fiscal year ending June thirtieth, nineteen hundred and three, and for other purposes.

* * * *

. . . Hereafter there shall be published of the American Ephemeris and Nautical Almanac two thousand five hundred copies, five hundred of which

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shall be for the use of the Senate, one thousand for the use of the House of Representatives, and one thousand for distribution or sale by the Navy Department.

1911—Act of March 4, 1911 (37 Stat. L., 360, 393)—An Act Making appropriation for the legislative, executive, and judicial expenses of the Government for the fiscal year ending June 30, 1913, and for other purposes.

* * * *

For assistants in preparing for publication the American Ephemeris and Nautical Almanac, namely: one at . . . who may act as or be appointed director.

1912—Act of August 22, 1912 (37 Stat. L., 328, 342)—An Act Making appropriations for the naval service for the fiscal year ending June thirtieth, nineteen hundred and thirteen, and for other purposes.

* * * *

The Secretary of the Navy is hereby authorized to arrange for the exchange of data with such foreign almanac offices as he may from time to time deem desirable with a view to reducing the amount of duplication of work in preparing the different national nautical and astronomical almanacs and increasing the total data which may be of use to navigators and astronomers available for publication in the American Ephemeris and Nautical Almanac: *Provided,* That any such arrangement shall be terminable on one year's notice: *Provided further,* That the work of the Nautical Almanac Office during the continuance of any such arrangement shall be conducted so that in case of emergency the entire portion of the work intended for the use of navigators may be computed by the force employed by that office, and without any foreign coöperation whatsoever: *Provided further,* That any employee of the Nautical Almanac Office who may be authorized in any annual appropriation bill and whose services in whole or in part can be spared from the duty of preparing for publication the annual volumes of the American Ehemeris and Nautical Almanac may be employed by said office in the duty of improving the tables of the planets, moon, and stars, to be used in preparing for publication the annual volumes of the office: *Provided further,* That section four hundred and thirty-five, Revised Statutes, is hereby repealed.

1916—Act of August 29, 1916 (39 Stat. L., 556, 577)—An Act Making appropriations for the naval service for the fiscal year ending June 30, 1917, and for other purposes.

* * * *

. . . Hereafter no further appointments shall be made to the Corps of Professors of Mathematics, and that corps shall cease to exist upon the death, resignation or dismissal of the officers now carried in that corps on the active and retired list of the navy.

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1925—Act of February 11, 1925 (43 Stat. L., 861, 868)—An Act Making appropriations for the Navy Department and the naval service for the fiscal year ending June 30, 1926, and for other purposes.

* * * *

. . . Naval Observatory, Salaries, Navy Department. For personal services in the District of Columbia, in accordance with the Classification Act of 1923, $82,000.

Contingent and Miscellaneous Expenses, Naval Observatory

Miscellaneous computations: For personal services in the District of Columbia, in accordance with the Classification Act of 1923, $9,300.

For professional and scientific books, books of reference, periodicals, engravings, photographs, and fixtures for the library, $1,000.

For apparatus and instruments, and for repairs of the same, $2,500.

For repairs to buildings, fixtures, and fences; furniture, gas, chemicals, and stationery, including transmission of public documents, through the Smithsonian exchange, foreign postage; plants, fertilizers, and all contingent expenses, $3,500.

For fuel, oil, grease, pipe, wire, and other materials needed for the maintenance and repair of boilers, engines, heating apparatus, electric lighting and power plant, and water-supply system; purchase and maintenance of teams; maintenance, repair, or operation of motor truck and passenger automobile and of horse-drawn passenger-carrying vehicles; material for boxing nautical instruments for transportation; paints, telegraph and telephone service, and incidental labor, $12,000, of which amount not to exceed $3,058 may be expended for personal services in the District of Columbia.

For cleaning, repair, and upkeep of grounds and roads, including personal services in the District of Columbia, in accordance with the Classification Act of 1923, $6,030, of which amount not to exceed $4,920 may be expended for personal services in the District of Columbia.

For expenses in preparing for and conducting observations of total solar eclipse of January 14, 1926, $3,670.

Salaries, Nautical Almanac Office

For personal services in the District of Columbia, in accordance with the Classification Act of 1923, $28,460.

For pay of computers on piecework in preparing for publication the American Ephemeris and Nautical Almanac and in improving the tables of the planets, moon, and stars, $2,500.

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APPENDIX 6

FINANCIAL STATEMENTS

Explanatory Note

Statements showing appropriations, receipts, expenditures and other financial data for a series of years constitute the most effective single means of exhibiting the growth and development of a service. Due to the fact that Congress has adopted no uniform plan of appropriation for the several services and that the latter employ no uniform plan in respect to the recording and reporting of their receipts and expenditures, it is impossible to present data of this character according to any standard scheme of presentation. In the case of some services the administrative reports contain tables showing financial conditions and operations of the service in considerable detail; in others financial data are almost wholly lacking. Careful study has in all cases been made of such data as are available, and the effort has been made to present the results in such a form as will exhibit the financial operations of the services in the most effective way that circumstances permit.

In the financial statement the figures since 1910 are on an accrual basis except where otherwise indicated. They were obtained from "Combined Statement of the Receipts and Disbursements, Balances, etc., of the United States," issued by the Treasury Department.

It was found convenient to combine some of the items of appropriation of earlier years in order to fit in and be comparable with the more recent items. Thus, the item "Contingent and miscellaneous expenses" in the table includes appropriations and expenditures for this item for both the Naval Observatory and the Nautical Almanac Office, and for instruments and accessories, miscellaneous computations, professional and scientific books, etc., and apparatus and instruments and repairs; and the item "Purchase of land, erection of buildings, etc., includes items designated purchase of land, erection of buildings, installation of water mains, nautical instrument repair shop, completing new Naval Observatory, purchase of site, etc."

The items relating to salaries in the financial statements do not include the pay and allowances of the ten commissioned naval officers detailed for service in the Naval Observatory, who are paid out of the appropriation, "Pay of the Navy."

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NAVAL OBSERVATORY

Appropriations, Fiscal Years by Five-Year Intervals, 1875 to 1910, Inclusive

Object	1875	1880	1885	1890	1895	1900	1905	1910
	Appropriation	Appropriation	Appropriation	Appropriation	Appropriation	Appropriation	Appropriation	Appropriation
Salaries, Naval Observatory..	$6,300	$6,100	$17,420	$21,720	$38,360	$38,720	$39,440	$43,240
Salaries, Nautical Almanac Office.	18,000	19,000	23,700	23,880	23,880	22,900	22,240	22,440
Contingent and Miscellaneous Expenses.[a]	[b]27,050	19,500	[c]14,736	8,136	37,456	12,000	16,750	18,750
Grounds and roads.....	.....	.....	.....	.....	12,000	10,000	7,800	10,000
Purchase of land, erection of buildings, etc.	.....	22,365	.....	.....	.....	.....	.....	.....
Observations of eclipse of the sun.	.....	3,450	.....	.....	.....	.....	5,000	.....
Totals	$51,350	$70,415	$55,856	$53,736	$111,696	$83,620	$91,230	$94,430

[a] For items included under this head see page 86.
[b] Includes last payment of $10,000 on refracting telescope.
[c] Includes $5,000 for reduction of observations of transit of Venus.

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Appropriations and Expenditures, Fiscal Years 1911 to 1926, Inclusive

Object	1911		1912		1913		1914	
	Appropriation	Expenditure	Appropriation	Expenditure	Appropriation	Expenditure	Appropriation	Expenditure
Salaries, Naval Observatory..	$43,240	$42,581.16	$43,240	$41,840.95	$43,240	$41,428.33	$44,240	$44,171.89
Salaries, Nautical Almanac Office.	22,440	22,182.79	22,640	21,460.39	22,640	20,605.01	22,640	22,466.12
Contingent and Miscellaneous Expenses.[a]	18,750	17,796.27	21,250	21,156.10	18,750	18,412.04	18,750	18,736.49
Ground and roads.....	10,000	9,924.58	5,009	4,957.83	5,000	4,998.48	5,000	4,999.82
Purchase of land, erection of buildings, etc.	.....	.....	.....	.....	.....	.....	.....	.....
Observations of eclipses of the sun.	.....	.....	.....	.....	.....	.....	.....	.....
Totals	$94,430	$92,484.80	$92,130	$89,415.27	$89,630	$85,443.86	$90,630	$90,374.32

Object	1915		1916		1917		1918	
	Appropriation	Expenditure	Appropriation	Expenditure	Appropriation	Expenditure	Appropriation	Expenditure
Salaries, Naval Observatory..	$44,240	$44,117.45	$44,240	$44,205.28	$44,240	$43,905.66	$47,040.00	$44,716.16
Salaries, Nautical Almanac Office.	22,640	22,512.49	22,240	22,190.30	22,240	22,166.71	22,240.00	21,208.22
Increase of Compensation....	.....	.....	.....	.....	.....	.....	3,622.83	3,622.83
Contingent and Miscellaneous Expenses.[a]	18,750	18,475.83	18,750	18,265.83	18,750	18,355.58	21,750.00	20,400.95
Grounds and roads.....	.....	.....	5,000	4,886.04	5,000	4,957.27	6,000.00	5,936.22
Purchase of land, erection of buildings, etc.[a]	.....	.....	.....	.....	.....	.....	20,000.00	[b]
Observations of eclipses of the sun.	.....	.....	.....	.....	.....	.....	3,500.00	1,844.84
Totals	$85,630	$85,105.77	$90,230	$89,547.45	$90,230	$89,385.22	$124,152.83	$97,729.22

[a] For items included under this head see page 86.
[b] Entire amount, $20,000 carried to surplus fund in 1922.

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APPROPRIATIONS AND EXPENDITURES, FISCAL YEARS 1911 TO 1926, INCLUSIVE—*Continued*

Object	1919		1920		1921		1922	
	Appropriation	Expenditure	Appropriation	Expenditure	Appropriation	Expenditure	Appropriation	Expenditure
Salaries, Naval Observatory..	$47,040.00	$40,280.27	$52,820.00	$51,729.13	$56,400.00	$54,527.58	$56,400.00	$56,194.38
Salaries, Nautical Almanac Office.	22,240.00	18,284.78	22,240.00	17,969.14	19,921.00	18,338.46	19,920.00	18,772.40
Increase of Compensation....	5,788.33	5,788.33	14,765.31	14,765.31	13,177.28	13,177.28	13,183.98	13,183.98
Contingent and Miscellaneous Expenses.[a]	[b]24,536.00	20,406.39	23,000.00	22,063.51	34,000.00	31,803.39	25,000.00	23,588.25
Grounds and roads.....	6,000.00	5,866.74	6,000.00	5,959.39	6,500.00	6,464.29	6,500.00	6,437.43
Purchase of land, erection of buildings, etc.[a]	.....	.....	.....	.....	.....	.....	.....	.....
Observations of eclipses of the sun.	.....	.....	.....	.....	.....	.....	.....	.....
Totals	$105,604.33	$90,626.51	$118,825.31	$112,486.48	$129,998.28	$124,311.00	$121,003.98	$118,176.44

Object	1923		1924		1925		1926	
	Appropriation	Expenditure	Appropriation	Expenditure [c]	Appropriation	Expenditure [d]	Appropriation	Expenditure
Salaries, Naval Observatory..	$56,400.00	$55,511.82	$54,000.00	$54,000.00	$79,260	$78,353.84	$82,000	
Salaries, Nautical Almanac Office.	19,920.00	19,825.73	19,920.00	19,920.00	30,960	30,481.24	30,960	
Increase of Compensation....	13,118.68	13,118.68	12,968.66	12,968.66	.....	.....	.....	
Contingent and Miscellaneous Expenses.[a]	24,000.00	23,489.19	24,000.00	21,858.70	26,500	25,371.03	28,300	
Grounds and roads.....	5,000.00	4,675.11	5,000.00	4,598.80	7,410	7,166.70	6,030	
Purchase of land, erection of buildings, etc.[a]	.....	.....	.....	.....	[e]19,041	.....	.....	
Observations of eclipses of the sun.	.....	.....	.....	.....	.....	.....	3,670	
Totals	$118,438.68	$116,620.53	$115,888.66	$113,346.16	$163,171	$141,372.81	$150,960	

[a] For items included under this head see page 86.
[b] Of this amount, $36 were transferred from the naval supply fund.
[c] Expended in 1924 and 1925.
[d] Expended in 1925.
[e] Includes $15,000 for installation of water mains.

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APPENDIX 7

BIBLIOGRAPHY[1]

Explanatory Note

The bibliographies appended to the several monographs aim to list only those works which deal directly with the services to which they relate, their history, activities, organization, methods of business, problems, etc. They are intended primarily to meet the needs of those persons who desire to make a further study of the services from an administrative standpoint. They thus do not include the titles of publications of the services themselves, except in so far as they treat of the services, their work and problems. Nor do they include books or articles dealing merely with technical features other than administrative of the work of the services. In a few cases explanatory notes have been appended where it was thought they would aid in making known the character or value of the publication to which they relate.

After the completion of the series the bibliographies may be assembled and separately published as a bibliography of the Administrative Branch of the National Government.

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Claims that appropriation for observatory had been made under head of depot for charts.

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INDEX

Abbe, Cleveland, 35.
Academy of Arts and Sciences, 22.
Activities, 46-58, 70, 71.
Adams, John Quincy, 5, 7, 8.
Administrative Assistant, Office of, 60.
Administrative Section, functions of, 60, 67.
Aeronautics, Bureau of, 57.
Air Navigation and Aerological Instrument Division, functions of, 33, 64. 69.
Airship, observation of solar eclipse from, 41.
Aleutian Islands, determining longitude of, 38, 51.
Algiers, observing station at, 51.
Allen, W. F., 35.
Almanac, Nautical. *See* American Ephemeris and Nautical Almanac.
Almanac offices, nautical, foreign, coöperation with, 52.
American Astronomical Society, 58.
American Ephemeris and Nautical Almanac, 1, 4, 22, 26, 27, 42, 43, 46, 51, 52, 72, 73.
American Metrological Society, 35.
American Philosophical Society, 4, 22.
Annapolis, time signals from, 50, 51.
Annual reports of Board of Visitors, 74.
Annual Reports of Superintendent, 72.
Arlington, time signals from, 50.
Assistant Superintendent, Office of, 59, 67.
Astronomical Branch, functions of, 61, 68.
Astronomical Council, functions of, 47, 59, 67.
Astronomical day, change of, 36.
Astronomical instrument, first erected in Washington, D. C., 10.
Astronomical Observations Department, functions of, 61, 68.
Astronomical observations, history of, 12, 14-16, 21-24, 38-41.
Astronomical Observatory, early efforts to establish, 2-8. *See also* Naval Observatory.
Astronomical organizations, coöperation with, 57, 58.
Astronomical Papers, 28, 73, 74.
Astronomical work, 21, 46-49, 53-57.
Astronomische Gesellschaft, 40.
Atlantic Coaster's Nautical Almanac, 73.
Australia, time signals to, 50, 51.
Auwers, Arthur, 40.
Aviation Section, establishment of, 33. *See also* Air Navigation and Aerological Instrument Division.

Balboa, Time Signals from, 50.
Barnette, William J., 44.
Belknap, George E., 44.
Bessel's Zone Observations, 21.
Bibliography, 90-96.
Board of Navy Commissioners, 9, 10, 11, 13, 14, 24.
Board of Visitors, 32, 33, 74.
Bond, William C., 12.
Bordeaux, France, time signals from, 50, 51.
Brooke, John, 23.
Buildings and Grounds, 61, 68.

Cambridge, Mass., Nautical Almanac Office at, 27.
Canada, time signals to, 50, 51.
Caribbean Sea, U. S. Surveying parties in, 38.
Catalogues of stars, 21, 22, 42, 51, 53, 63.
Cavite, Philippine Islands, time signals from, 50.
Charleston, South Carolina, time signals from, 50.
Chester, Colby M., 44.
Chief of Engineers of the Army, 37.
Chile, Expedition to, 22, 26.

Digitized by Google

Chronograph, first installation of, 22.
Chronometers, testing and rating of, 10, 46, 51.
Clark, Alvan, 30.
Clocks, Riefler, 49, 77.
Coast and Geodetic Survey, 6, 11, 37, 38, 39, 51, 52.
Coast Guard, 52.
Coast Survey. *See* Coast and Geodetic Survey.
Coffin, John H. C., 45.
Committee on Ephemerides, 58.
Computing Section, functions of, 60, 67.
Congrès International des Éphémérides Astronomiques, 42, 43.
Conférence Internationale des Étoiles Fondamentales, 42.
Connaissance des Temps, 44.
Contributions to Current Scientific Literature, 75.
Coöperation of foreign nautical almanac offices, 52.
Coöperation with astronomical organization, 51, 52, 57, 58.
Corona, solar, 54, 55.

Davis, Charles Henry, 27, 44, 45.
Davis, Charles Henry, 2d, 44.
Depot of Charts and Instruments: erection of permanent buildings for, 13-17; establishment of, 8; functions of, 9-15; work of, 17-24; legal status of, 24-26.
De Wallenstein, 6.
Dowd, Charles F., 35.

Eclipses, solar, observations of, 38-41, 51, 54, 55.
Eichelberger, William S., 45.
Electric disturbances, 54, 55.
Engineering, Bureau of, Navy Department, 54.
England, time signals to, 50.
Ephemerides, Committee on, 58. *See also* American Ephemeris and Nautical Almanac.
Ephemeris. *See* American Ephemeris and Nautical Almanac.
Equatorials Division, functions of, 61, 68.
Equipment, Bureau of, Navy Department, 29.
Equipment of Naval Observatory, 76-78.
Eureka, California, time signals from, 50.
Executive Committee, functions of, 48, 60, 67.
Exploring Expeditions, 11-13, 19, 26.

Fillebrown, T. S., 29.
Financial Statements, 86-89.
Fleming, Sanford, 35.
Foreign almanac offices, coöperation with, 42, 43, 52.
Foreign countries, use of time signals by, 51.
Foreign time signals, receipt of, 50.
France, coöperative arrangements with, 52.
France, time signals to, 50.
Franklin, Samuel R., 44.
Functions of Depot of Charts and Instruments, 9-15; Nautical Almanac Office, 51; Naval Observatory, 1, 46-48. *See also* Activities.

General Land Office, 52.
Germany, Coöperative arrangements with, 52.
Gilliss, James M., 12, 14, 16, 17, 20, 22, 23, 26, 44, 74.
Goldsborough, Louis M., 9-11, 23, 44.
Great Britain, coöperative arrangements with, 52.
Great Lakes, time signals from, 50.
Greenwich, meridian of, 27, 28, 42, 43.
Gyro-compass, development of, 57.
Gyro-Compass Division, function of, 64, 69.

Hall, Asaph, 39.
Harkness, William, 45.
Harshman, Walter S., 45.
Hassler, Ferdinand R., 11.
Hendrickson, William W., 45.
Hill, tables of, 43.
History of: Depot of Charts and Instruments, 8-26; Nautical Almanac Office, 26-28; Naval Observatory, 28-45.

Digitized by Google

Hoogewerff, John A., 44.
Howard, Thomas B., 44.
Hydrographic Office, 1, 23, 24, 25, 27, 29, 55.
Hydrographic work, 11, 14, 15, 17-20, 26.

Illustration of Naval Observatory, 30.
Inspection Division, functions of, 65, 69.
Instruction of Naval Officers in field astronomy, 55.
Instruments, astronomical, etc., at Naval Observatory, 32, 46, 56, 57.
International Astronomical Union, 58.
International conferences, 20, 37, 41-44, 57.
International photographic survey of the heavens, 53.
International time comparisons, 50.

Japan, expedition to, 19, 26.
Jayne, Joseph L., 44.

Key West, time signals from, 50.

Lag in transmission of time signals, 50.
Lalande's Catalogue, 22.
Lambert, William, 2-5.
Latitude, observations for variation of, 54.
Laws, 79-85.
Legal Status of the Depot of Charts and Instruments, 24.
Library, 60, 67, 74, 78.
Lighthouses, Bureau of, 52.
Longitude determinations, 2, 3, 4, 12, 37, 50, 51.
"Los Angeles" (airship), 41.

MacDougall, Wm. D., 44.
McNair, Frederick V., 44.
Macomb, A., 5, 6.
Magnetic Compass Division, functions of, 64, 69.
Magnetic storms, 54, 55.
Magnetic work, 12, 14, 15, 17, 18.
Manila Observatory, Cavite, Philippine Islands, time signals from, 35.
Mare Island Navy Yard, chronometer and time station at, 35, 36, 50.
Mars, discovery of satellites of, 39.
Material, Department of, functions of, 63, 69.
Maury, Matthew F., 17, 19, 20, 23, 44.
Mercury, transit of, 41.
Meridian, common prime, adoption of, 41, 42.
Meridian of Greenwich, 27, 28, 42, 43.
Meridian of Washington, 2-5, 27, 28, 42, 43.
Meteorological work, 12, 14, 15, 17, 18, 20, 23, 26.
Mexico, time signals to, 50, 51.
Minor planets, discovery of, 23.
Monroe, James, 2, 3.

National Academy of Science, 39.
Nautical Almanac. *See* American Ephemeris and Nautical Almanac.
Nautical Almanac Department, functions of, 63, 68.
Nautical Almanac, Director of the, 42.
Nautical Almanac Office, activities, 51, 52, 63; executive heads, 45; history, 26-28. *See also* American Ephemeris and Nautical Almanac.
Nautical Branch, functions of, 63, 69.
Nautical Instruments and the Time Service Division, functions of, 65, 69.
Naval Intelligence, Office of, 46.
Naval Observatory, accessible to visitors, 32; early efforts to establish, 2-8; executive heads, 44; illustration, 30; latitude, longitude, and elevation, 31, 32; legal status, 24-26, 28, 29 (*See also* Laws); rank as a naval station, 29; site for, and erection of, 30, 31.
Naval Observatory Publications, Second Series, 74.
Naval officers, instruction of, in field astronomy, 55.
Navigation, Bureau of, Navy Department, 1, 24, 29.

Digitized by Google

Navigational Instruments, work on, 56, 57.
Neptune, discovery of, 22.
Newcomb, Simon, 45.
Newcomb, tables of, 43.
New Orleans, time signals from, 50.
New York, time signals from, 50.
New Zealand, time signals to, 50, 51.
Nine-Inch Transit Circle Division, functions of, 62, 68.
Norfolk, Virginia, time signals from, 50.
North Head, Washington, time signals from, 50.
North Pacific and Arctic Surveying Expedition, Rodgers, 19, 23, 26.

Observatory. *See* Naval Observatory.
Observatory Circle, establishment of, 31, 32, 81, 82.
Ordnance and Hydrography, Bureau of, 24.
Organization, 59, 69.

Pacific Coaster's Nautical Almanac, 73.
Pacific Ocean and South Seas Exploring Expedition, Wilkes, 11-13, 26.
Paraguay Expedition, 26.
Pearl Harbor, Hawaiian Islands, time signals from, 50, 51.
Perry, Matthew G., 19, 26.
Philadelphia, time signals from, 50.
Photographic Survey of the heavens, international, 53.
Photographic Zenith Tube and Alt-Azimuth Division, functions of, 62, 68.
Phythian, Robert L., 44.
Planets, Minor, discovery of, 40.
Plant and Equipment, 76-78.
Pollock, Edwin T., 44.
Postal Telegraph Company, time distribution by, 50.
Prime Vertical Transit Instrument Division, functions of, 63, 68.
Publications, 72-75.
Publications of the U. S. Naval Observatory, Second Series, 74.

Radio Research Laboratory, United States, 54.
Refracting telescope, twenty-six-inch, 30.
Repair shop, description of, 78.
Repair shop for instruments, 33, 56.
Ringgold, Cadwalader, 19.
Rodgers, John, 19, 44.
Rowan, Stephen C., 44.

San Diego, California, time signals from, 38, 50, 51.
Sands, Benjamin F., 44.
San Francisco, time signals from, 50.
Saturn, orbits of satellites of, 63.
Secretary of the Navy, 6, 10, 12, 14, 16, 22, 24, 26-28, 46.
Shanghai, observing station at, 51.
Shufelt, Robert W., 44.
Site for Naval Observatory, 30, 31.
Six-Inch Transit Circle Division, functions of, 62, 68.
Smithsonian Fund, 6, 7, 8.
Solar corona, 54, 55.
Solar eclipses, 38-41, 51, 54, 55.
South Africa, time signals to, 50.
Spain, coöperative arrangements with, 52.
Standard time, 34, 35, 36, 46, 49.
Stars, catalogues of, 21, 22, 42, 51, 53, 63.
Sun, eclipse of. *See* Solar eclipses.
Sun, photographs of, 54.
Sun spots, 54.
Superintendent of the Naval Observatory, 25, 33, 47.
Superintendent, Office of, 59, 67.
Supply Division, functions of, 65, 69.
Survey of the Coast. *See* Coast and Geodetic Survey.
Swiss Boundary Commission, 38.

Telescope, twenty-six-inch refracting, 30.
Time balls, 34, 35.
Time pieces, testing and rating, 51.
Time Service, activities, 48-51; history, 34-36.
Time signals, 34-36, 38, 49-51, 56.
Time, standard, 34, 35, 36, 46, 49.
Todd, Henry D., 45.

Digitized by Google

Transit of Mercury, 41.
Transit of Venus, 39, 40.
Transit of Venus Commission, 39.
Troughton, Edward, 11.
Tutuila, American Samoa, observations at, 33.

U. S. Naval Observatory. *See* Naval Observatory.
Updegraff, Milton, 45.

Van Buren, Martin, 7.
Veeder, T. E. D. W., 44.
Venus, transit of, 39, 40.
Vessels at sea, time signals to, 50.
Visitors to Naval Observatory, 55.

Walker, Asa, 44.
Walkers, Sears C., 22.
War activities, 20, 36, 56.
War Department, 52.
Washington, meridian of, 2-5, 27, 28, 42, 43.
Washington Observations, 22, 74.
Washington Observatory. *See* Naval Observatory.
Weather Bureau, 52.
Western Union Telegraph Co., 34, 37, 50.
Wilkes, Charles, 11-13, 17, 23, 26, 37, 44.
Wind and current charts, 26.
Winlock, Joseph, 45.

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